

Age Differences in Suggestibility Following Semantic Illusions:

The Role of Prior Knowledge

by

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Dissertation submitted in partial fulfillment of  
the requirements for the degree of Doctor  
of Philosophy in the Department of  
Psychology & Neuroscience in the Graduate School  
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ABSTRACT

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## **Abstract**

In the face of declines in memory related to specific events, people maintain intact general knowledge into very old age. Older adults often use this knowledge to support their remembering. Semantic illusions involve situations in which presented information contradicts correct knowledge; the illusion occurs when people fail to notice a contradiction with what they know. Compared to younger adults, older adults' later memories are surprisingly less affected by semantic illusions. That is, they use fewer errors seen in the semantic illusions as answers when later asked related general knowledge questions. Why do older adults show this reduced suggestibility, and what role does their intact knowledge play? In 5 experiments, I explored these questions. Older adults' reduced suggestibility was not due to an age difference in error detection: older adults were no better than younger adults at detecting the errors that contradicted their stored knowledge. In addition, episodic memory failures were not a major factor either; the evidence for their direct involvement was mixed. Instead, prior knowledge seems to have been particularly protective for older adults. They demonstrated more knowledge to begin with but also gained access to even more of their stored knowledge across the duration of experiments, leading them to be less suggestible following semantic illusions. There was also an indication that when knowledge was stably accessible, older adults had a tendency to rely on it more than did younger adults.

Broadly, these findings indicate that older adults' intact prior knowledge provides important benefits to their remembering and can even protect them against acquiring erroneous information about the world.

## **Dedication**

I dedicate this body of work to Swami and to my parents. Without Your constant support, underlying guidance and ever-present Love in my life, I could never have accomplished this or anything else. Thank you; this is all because of and for You.

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# 1. Introduction<sup>1</sup>

While other aspects of memory decline in healthy aging (for reviews, see Balota, Dolan, & Duchek, 2000; Craik & Jennings, 1992; Park, 2000), memory for knowledge remains relatively intact and in fact, can actually improve (e.g., Mitchell, 1989; Light & Anderson, 1983; McIntyre & Craik, 1987). Here, “knowledge” refers broadly to general knowledge about the world, vocabulary, schemas, work-related skills, and practical abilities gained over a lifetime. From an anthropological perspective, the maintenance and impact of preexisting knowledge in aging may reflect a potential shift in memory function from knowledge acquisition (i.e. new learning) to knowledge dissemination, which is fitting since old age is the only stage of life that is not forward looking (see Hess, 2005; Hess & Pullen, 1996). In this context, remembering the details of specific events is less important (Butler, 1974; Cohen, 2005) and instead, memory is more affected by values, goals, prior knowledge, and emotion (Castel, 2008; Fung & Carstensen, 2003; Hess, 2006). When prior knowledge is discussed in the aging and memory literature, it is emphasized as leading older adults astray in remembering, such that they think stereotypically, generalize inappropriately, forget new information that

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<sup>1</sup> Parts of this chapter have been accepted for publication in a larger manuscript at *Perspectives on Psychological Science*.



does not fit with what they already know, and falsely remember items that they did not actually encounter. However, prior knowledge can also facilitate accurate remembering, sometimes eliminating age differences in memory performance or even leading older adults to outperform their younger counterparts.

I am most interested in the potential benefits that intact knowledge can provide older adults in remembering. As such, the focus of this dissertation is on the influence of older adults' robust prior knowledge on their suggestibility following semantic illusions. Semantic illusions involve situations in which presented information contradicts correct knowledge; the illusion occurs when people fail to notice a contradiction with what they know. Younger adults' memories are affected by these semantic illusions such that they often use the errors that they saw to answer later related general knowledge questions (e.g., Marsh, Meade, & Roediger, 2003; Bottoms, Eslick, & Marsh, 2010). Whereas older adults typically show increased suggestibility and make more memory errors compared to younger adults (e.g., Cohen & Faulkner, 1989; Schacter, Koutstaal, Johnson, Gross, & Angell, 1997; Thomas & Bulevich, 2006), here, older adults' later memories are surprisingly less affected by semantic illusions. That is, they use fewer errors seen in the semantic illusions as answers when later asked related general knowledge questions. Why do older adults show this reduced suggestibility, and what role does their intact knowledge play? In 5 experiments, I explored these questions, examining the possible

protective nature of older adults' prior knowledge in suggestibility following semantic illusion scenarios.

In the sections that follow, I briefly review the state of memory function in healthy aging with a focus on older adults' intact knowledge, provide examples of the positive and negative effects of knowledge on older adults' remembering, and introduce relevant theories of cognitive aging. Finally, I discuss older adults' suggestibility to episodic and semantic errors and propose explanations for why they might be less suggestible following semantic illusions than are younger adults.

## ***1.1 Memory in Healthy Aging***

### **1.1.1 Declines in Memory for Specific Events in Healthy Aging**

Across a variety of materials and experimental procedures, older adults exhibit difficulties remembering details related to particular events (i.e. episodic memories; for reviews, see Craik & Jennings, 1992; Balota et al., 2000), such as words (e.g., Perlmutter, 1978; Park, 1996; Park & Shaw, 1992; Shaw & Craik, 1989), narratives (Adams, 1991; Cohen, 1979; Reder, Wible, & Martin, 1986) and contextual details (Burke & Light, 1981; Hess & Pullen, 1996; Light, 1992; Park & Puglisi, 1985). More specifically, older adults show deficits in memory for source details (Craik, 1986; Hashtroudi, Johnson, & Chrosniak, 1989), struggling to distinguish internal sources (Rabinowitz, 1989), different external sources (Kausler & Puckett, 1981), and even between internal and external

sources (McIntyre & Craik, 1987). Thus, older adults show a variety of difficulties in remembering events and the specific details associated with those events. These difficulties are often used to explain older adults' memory performance.

### **1.1.2 Intact Knowledge in Healthy Aging**

However, not all of memory suffers (Dixon, 2003; Glisky & Glisky, 1999; Schaie, 1996; Schaie & Labouvie-Vief, 1974). For example, older adults maintain 60-80% of their memories for their college grades as many as 54 years after graduating (Bahrick, Hall, & Da Costa, 2008) and similarly, remain almost completely unimpaired on recognizing names and faces of high-school classmates up to 57 years later (Bahrick, Bahrick, & Wittlinger, 1975). More specifically, knowledge, associated with crystallized intelligence (Cattell, 1963; Labouvie-Vief, 1977; Schaie, 1970; Schretlen, Pearlson, Anthony, Aylward, Augustine, Davis, & Barta, 2000), is spared and often increases with age (Cornelius & Caspi, 1987; Staudinger, Cornelius, & Baltes, 1989). For instance, people appear to maintain and continue adding to their vocabularies with advancing age (e.g., Arbuckle, Cooney, Milne, & Melchior, 1994; Bahrick, 1984; Bowles & Poon, 1985; Burke & Peters, 1986; Mitchell, 1989; Perlmutter, 1978). Furthermore, from generating scripts detailing everyday activities (Light & Anderson, 1983) to judging the plausibility of events taking place within particular story-contexts, older adults perform no differently from younger adults (Reder et al., 1986). More generally, although older adults may be slower to

respond and sometimes struggle to retrieve their knowledge (e.g., Brod et al., 2013; Burke & Shafto, 2004), they typically remember many more facts about the world correctly than do younger adults (e.g., Botwinick & Storandt, 1980; McIntyre & Craik, 1987; Perlmutter, 1978). Such knowledge-related memories are not associated with memories of particular instances but have been acquired through countless learning experiences in formal education and daily life (Charness & Bieman-Copland, 1992; Lachman & Lachman, 1980).

For the most part, older adults are adept at applying their knowledge effectively when needed (see reviews: Charness & Bieman-Copland, 1992; Craik, 2000; Hoyer, Rybash, & Roodin, 1989; Lachman & Lachman, 1980; Light, 1991, 1992; Light & Burke, 1988; Salthouse, 1982; in contrast, see Peelle, Chandrasekaran, Powers, Smith, & Grossman, 2013). For instance, capitalizing on their intact vocabularies, older adults show high levels of agreement with their younger counterparts when determining if specific words fit particular sentence-contexts (Little, Prentice, & Wingfield, 2004). Older adults are also still able to use domain-specific knowledge from their formal educations; impressively, Bahrick and Hall (1991) found that high-school level math knowledge was often maintained over the course of 50 years. Overall, these intact abilities suggest that older adults are capable of bringing their considerable knowledge to bear in a variety of situations.

Knowledge seems to remain so robust in older adults that Charness suggests that perhaps “acquired knowledge is the magic potion that allows older workers to avoid declines in processing efficiency” (2000). Whether testing typists (Salthouse, 1984), pianists (Krampe & Ericsson, 1996), pilots (Hardy & Parasuraman, 1997; Morrow, Leirer, Altieri, & Fitzsimmons, 1994), bank managers (Colonia-Willner, 1998, 1999), graphic designers (Lindenberger, Kliegal, & Baltes, 1992), accountants and bookkeepers (Castel, 2007) or professors (Shimamura, Berry, Mangels, Rusting, & Jurica, 1995), older adults in the work force typically do not show decrements in their productivity or expertise in their field due to aging (see also, Charness, 1981; Perlmutter, 1988; Salthouse, 1994; Waldman & Alvolio, 1986, 1993; in contrast, Mainz & Salthouse, 1998; Salthouse, 1990).

The discussed evidence flies in the face of unfortunate but widely held beliefs that old age is a time of degradation and a lack of productivity (Butler, 1974). Instead, some researchers even consider older adults to be natural general knowledge “experts” through a lifetime of learning (Hoyer et al. 1989; Perlmutter, 1988).

## ***1.2 The Role of Prior Knowledge in Older Adults’ Remembering***

### **1.2.1 Costs of Reliance on Knowledge**

Across many studies, older adults are more likely to falsely recognize and recall things that are consistent with their prior knowledge than are younger adults, thereby making errors of commission as well as errors of omission (for reviews, see Schacter,

Koutstaal, & Norman, 1997; Schacter, Norman, & Koutstaal, 1998). In the literature, when the influence of prior knowledge on older adults' remembering is discussed, the emphasis is on how knowledge can lead older adults astray (e.g., Alba & Hasher, 1983; Burke & Light, 1981; Charness, 2000). The literature is full of examples showing that prior knowledge can be persistent to a degree that is no longer facilitative, leading older adults to think stereotypically, generalize inappropriately, and falsely remember items that they did not actually encounter (e.g., Botwinick, 1984; Arbuckle et al., 1994; Ceci & Tabor, 1981; Labouvie-Vief & Schnell, 1982). I review several of these examples here.

Botwinick put forth that "advanced age is associated with a lowered ability to unlearn that which is already integrated into well-established thought and behavior systems" (1984, p. 71). When asked to explicitly go against prior knowledge, older adults find it very difficult to comply. For instance, compared to younger adults, older adults struggle when asked to recall *false* multiplication equations (e.g.,  $3 \times 4 = 2$ ) that violate pre-existing knowledge of multiplication products as much as when asked to recall nonsense equations (e.g.,  $E \times Z = G$ ; Ruch, 1934). A very similar result was observed in the domain of spelling. MacKay, Abrams, and Pedroza (1999) found that while older and younger adults were equally able to correctly note misspellings, older adults struggled to reproduce recently studied misspellings. Older adults were also impaired when recalling correctly spelled words, but less so than for the misspelled words, for

which they could not rely on prior knowledge. Unfortunately, there was no measure of “intrusions” of correct spellings in place of the studied misspellings (when participants were asked to recall misspellings), which would directly indicate that older adults used their prior knowledge in reconstructing the spellings. Similarly, Howard (1988) found that older adults persisted in spelling homophones (e.g., great/grate) in the most frequently used way (e.g., great), even after hearing a sentence that used the infrequent form (e.g., grate), unlike younger adults.

A fourth example involves remembering stories, wherein Dalla Barba et al. (2010) found that older adults had such robust prior knowledge of famous fairy tales that they had difficulty learning and remembering modified versions of these well-known stories. That is, older adults produced significantly more intrusions of events and details from the original fairy tales (referred to as “confabulations” in their study) than younger adults when asked to recall modified well-known fairytales. Since there were no age differences in learning and recalling *novel* fairytales, this result does not appear to be due to an episodic memory deficit alone (see also De Anna, Attali, Freynet, Foubert, Laurent, Dubois, & Dalla Barba, 2008). Instead, older adults seem to use the overlearned original versions of the fairytales when attempting to recall the modified ones they recently read in the experiment.

In addition, consider work by Koutstaal and colleagues, where younger and older adults are asked to remember lists of related pictures (e.g., a series of musical instruments; all objects are common ones). At test, older adults are more likely to falsely recognize related but non-presented pictures (e.g., a harp) than are younger adults (Koutstaal & Schacter, 1997; Koutstaal, Schacter, & Brenner, 2001). To examine the contribution of prior knowledge, Koutstaal, Reddy, Jackson, Prince, Cendan, & Schacter (2003) had participants study ambiguous pictures. Critically, half of the subjects received familiar labels (e.g., “lamp”) that made it possible to interpret the ambiguous pictures (see Figure 1), whereas the others did not.



**Figure 1: Example ambiguous stimuli from Koutstaal et al. (2003).**

On a later recognition test, older and younger adults performed similarly in the no-label condition and were unlikely to false alarm to perceptually related but non-presented pictures. In contrast, in the condition where the pictures had been labeled initially, older adults made many more false alarms to the new related pictures than did the younger adults. Age-related increases in false recognition were only observed in the condition where older adults could bring their prior knowledge to bear, namely the



condition where the ambiguous figures had received familiar labels at study (see Simons, Lee, Graham, Verfaellie, Koutstaal, Hodges, Schacter, & Budson, 2005 for converging evidence from semantic dementia patients).

Similarly, after studying generic scenes (e.g., a kitchen), older adults are more likely than younger adults to claim they had seen prototypical objects (e.g., a pot) that were not actually presented (versus less common ones; Hess & Slaughter, 1990). The most famous version of this scenario is the Deese-Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995), where participants study lists of highly related words (e.g., bed, rest, tired, snooze...) and are later likely to falsely recall and recognize a critical related but non-presented word (e.g., sleep). The DRM illusion is stronger in older adults than younger adults, in both recall and recognition (Norman & Schacter, 1997; Balota, Cortese, Duchek, Adams, Roediger, McDermott, & Yerys, 1999; Butler, McDaniel, Dornburg, Price, & Roediger, 2004; Roediger & McDaniel, 2006; Tun, Wingfield, Rosen, & Blanchard, 1998), with older adults also intruding more other related words (Balota et al., 1999). A similar result occurs after studying lists of category exemplars (as opposed to associates), with older adults more likely to falsely recall non-presented exemplars than younger adults (Meade & Roediger, 2006; see also, Rankin & Kausler, 1979; Smith, 1975).

This collection of evidence demonstrates that when reconstructing memories for particular events and the details of those events, prior knowledge often leads older adults to make memory errors. It is this misleading influence of prior knowledge that is generally emphasized when it is discussed as a relevant factor in older adults' episodic memory performance.

### **1.2.2 Benefits of Knowledge**

Though prior knowledge is typically described as leading older adults astray when remembering, a small literature demonstrates that it can also be beneficial. The very same mechanisms can facilitate older adults' veridical reconstruction of episodic memories. Of course, both younger and older adults benefit from applicable stored knowledge, with prior knowledge facilitating learning under a variety of circumstances (Anderson, 1981; Bransford & Johnson, 1972; Glynn, Britton, & Muth, 1985; Kule & Healy, 2007; Kule, Healy, Fierman, & Bourne, 2010; Schustack & Anderson, 1979) and influencing our responses when we are forced to guess (Jacoby, Marsh, & Dolan, 2001). However, there are many situations in which older adults' performance improves significantly *more* (relative to any benefits that younger adults may experience) when general knowledge is applicable, often even extinguishing age differences in memory (Craig & Jennings, 1992; Hess, 1990, 2005; Hess & Pullen, 1996; Laurence 1967a, 1967b; Reyna & Mills, 2007; Woodruff-Pak & Hanson, 1995). This differential improvement in

older adults' memory for the details of recent events demonstrates that prior knowledge can bolster their remembering and does not always lead them astray.

For example, Castel (2005) demonstrated that how true to life grocery prices are affects older adults' recall of prices. Younger and older adults studied pictures of common groceries, each of which was priced to be reflective of market value or an unusual price; at test, participants were asked to recall the price of each grocery item. Realism of price did not affect younger adults' memories, but had a large impact on older adults, who remembered many more realistic prices than unusual ones. This benefit of realistic prices was strong enough to boost older adults' recall of *realistic* grocery prices to the level observed in younger adults. Of course, this result could be interpreted as evidence that older adults were unable to learn new unusual prices (with prior knowledge interfering with their ability to update prices) just as easily as the current emphasis on prior knowledge supporting memory for realistic prices. However, by their very nature, typical information is encountered more often in every day experiences, and therefore memory for such material is likely to be more useful than memory for abnormal, atypical, perhaps anomalous information.

Knowledge can also help older adults remember details in narratives. In a set of studies, Hess and colleagues asked participants to read passages about a character named Jack eating at a restaurant that contained both typical actions (e.g., "Jack asked

the waiter for the check”) and atypical actions (e.g., “Jack put a pen in his pocket”; Hess, 1985). Older adults showed a larger advantage for typical actions (over atypical) than did younger adults. More generally, the more prior knowledge older adults can apply, the smaller the age difference in memory (Hess & Tate, 1992; see also, Hess, Donley, & Vandermaas, 1989).

Similarly, knowledge can bolster older adults’ memories in spatial cognition (Arbuckle et al., 1994, Exp 3). Older and younger adults studied a layout that matched people’s schemas for a prototypical one-story house. Critically, some participants were told the layout was a “building” and others were told it was a “house”. Younger and older adults later performed similarly when reconstructing the house, but younger adults out-performed older adults when the layout had been labeled as a building. The authors suggest that this difference emerged because older adults could utilize their schematic knowledge for typical house layouts to facilitate their remembering of the blueprints. In contrast, younger adults showed no difference in memory performance based on the layout labels. That is, younger adult performance did not depend on the relevance of the schema activated, whereas older adults improved when the right schema was activated, to the point of eliminating age differences in memory.

Older adults can even remember more words than younger adults if the study phase capitalizes on their intact schematic verbal knowledge (Matzen & Benjamin, 2013).

In this study, older and younger adults studied words presented alone (e.g., tailspin, floodgate) and words embedded in sentences (e.g., The fighter plane went into a tailspin after it was hit by enemy fire.) On a subsequent recognition test, older adults were better than young adults at recognizing words that had been studied in sentences. Older and younger adults were equally likely to mistakenly accept new items (false alarms) and there were no age differences in correctly recognizing words that had been studied alone. Critically, the authors attribute older adults' superior performance to "skills honed through years of reading expertise," (p. 765) allowing them to make better use of the sentence contexts.

Older adults use their existing knowledge, schemas, and other overlearned information to help them reconstruct memories for particular events and the details associated with those events. Of course, these data can also be used to argue for an age-related deficit, since older adults' performance suffers more when they are unable to use prior knowledge, as compared to younger adults. The aging and memory literature tends to emphasize this "glass half empty" perspective whereas our point is to focus on the "glass half full" perspective. The implications of the glass-half-full perspective could have cascading benefits for the field and for older adults' everyday memory experiences.

Many literatures have these kinds of varying perspectives, where the same data or domain can yield entirely different interpretations. For example, consider the

treatment of heuristics and biases in the decision-making literature (see Kahneman & Klein, 2009). Some researchers focus on how these heuristics can lead us to make errors (i.e., errors of intuitive judgment; e.g., Tversky & Kahneman, 1974) whereas others focus on how such heuristics can support decision-making (i.e., the marvels of experts; e.g., Klein, Calderwood, & Clinton-Cirocco, 1986). Kahneman and Klein, two strong advocates for the different perspectives respectively, concluded that both positions are true and “the sharpest differences between [them] are emotional rather than intellectual” (2009; p. 518). Similarly, returning to the contrasting views at hand, the difference may simply be emotional to some degree. Regardless of whether the glass-half-full or glass-half-empty perspective is taken here, the bottom line is that older adults are often capable of matching (and sometimes, outperforming) younger adults when prior knowledge can be utilized.

### **1.2.3 Relevant Theories of Cognitive Aging**

Prior knowledge clearly influences remembering in older adults. The following sections discuss relevant theories of cognitive aging that provide insight into possible mechanisms by which older adults are influenced by their knowledge.

#### **1.2.3.1 Proactive Interference and Inhibition**

Older adults’ tendency to over-rely on their domain-specific knowledge is consistent with age-related declines in controlled processes (e.g., inhibition) while

automatic processes remain intact. More automatic processes, including accessing knowledge, are thought to require less conscious effort and are maintained with advancing age (Craik & Jennings, 1992; Hasher & Zacks, 1979; Light, 1991, 1992; Roediger, Balota, & Watson, 2001). As reviewed below, this deficit in control processes translates into problems resolving interference and inhibiting knowledge when it is not relevant.

Older adults' proclivity to automatically retrieve existing knowledge seems to be a clear instantiation of proactive interference, wherein older memories block access to more recently encountered information. In general, older adults tend to be more susceptible to proactive interference, compared to younger adults (for reviews, see Jacoby, Hessels, & Bopp, 2001; Winocur, 1982). Older adults have this problem when remembering word triplets (Jacoby, Wahlheim, Rhodes, Daniels, & Rogers, 2010), lists of objects (Loewenstein, Acevedo, Agron, & Duara, 2007) and faces (Flicker, Ferris, Crook, & Bartus, 1989), among other things. For example, consider a modified AB-AC task requiring participants to learn lists of words to criterion, wherein participants learned one set of word pairs (A-B) and then another set (A-C). When participants were asked to recall the AC list (given the A part of the pair), older adults remembered fewer AC word pairs and instead reported items from the AB list, demonstrating greater susceptibility to PI than did younger adults (Ebert & Anderson, 2009). Proactive interference causes

problems for older adults when completing the Stroop task (Borella, Delaloye, Lecerf, Renaud, & de Ribaupierre, 2009) and when making social judgments based on trait information (Hess, McGee, Woodburn, & Bolstad, 1998). At times, this increased susceptibility can result in benefits (e.g., Kim, Hasher, & Zacks, 2007; see also, Rowe, Valderrama, Hasher, & Lenartowicz, 2006) or in costs (e.g., Ebert & Anderson, 2009).

Many of these data can be interpreted as evidence that older adults' inhibitory deficits contribute to their over-reliance on knowledge (Hasher & Zacks, 1979, 1988; Hasher, Tonev, Lustig, & Zacks, 2001; Hay & Jacoby, 1999; Jacoby & Rhodes, 2006; Lustig, Hasher, & Zacks, 2007). That is, once information is partially active, older adults struggle to suppress that potentially irrelevant information (e.g., Balota et al., 2000; Hasher & Zacks, 1979, 1988; Kensinger & Schacter, 1999; Malmstrom & LaVoie, 2002), even when explicitly asked to do so (e.g., Anderson, Reinholz, Kuhl, & Mayr, 2011; Duchek, Balota, Faust, & Ferraro, 1995). Hasher & Zacks (1988) correctly predict that older adults are then more likely to use information that is easily accessible and rely on contextual cues rather than searching memory, seen in the memory phenomena described above. The most relevant result is that the application of prior knowledge becomes rather heavy-handed.

Both mechanisms are likely involved in the patterns observed here, and the difficulty is in separating their unique contributions. More generally, the point is that



knowledge disrupts the retrieval of new information, either by blocking access or through an inability to inhibit a preponderant response.

#### **1.2.3.2 Automatic versus Controlled Processes in Aging**

Older adults' tendency to over-rely on knowledge is consistent with dual process theories of aging, which make a distinction between controlled and automatic processing. As described earlier, older adults have deficits in controlled processing, which translate into difficulties with encoding and retrieving episodic memories (Craik, 1986; Hess, 2005). But, knowledge has been characterized as being applied automatically (e.g., Craik & Jennings, 1992; Light, 1991, 1992), with knowledge coming online whenever applicable (e.g., Balota et al., 2000; Hess et al., 1998; Lachman & Lachman, 1980; Light, 1991; 1992; Naveh-Benjamin, et al., 2005). As a result, knowledge, in its many forms, is automatically accessed and applied when people try to understand the world (Hess, 1990; Labouvie-Vief & Schnell, 1982). Older adults seem to be particularly likely to do so and may then overcompensate for potential deficits in the efficiency of controlled processes related to memory (Hess, 1990; Wingfield & Stine, 1991).

### **1.3 Semantic Illusions**

Again, semantic illusions involve situations in which presented information contradicts pre-existing knowledge. The illusion occurs when people fail to notice a

contradiction with what they already know. For example, it is a semantic illusion when a reader answers the question “where were the survivors buried?” after reading a short passage about a plane crash (Barton & Sanford, 1993), because this question contains a presupposition that contradicts the stored meaning of the word “survivor.” Falling for such a semantic illusion is a demonstration of people neglecting their stored knowledge (for further discussion, Marsh & Umanath, in press). Critically, exposure to the misleading content in semantic illusions can have consequences for memory. Testing general knowledge after exposure to semantic illusions, and the misleading content therein, allows for examining these consequences. That is, we can examine if and how often participants reproduce errors that they saw in the semantic illusion scenarios in response to questions that are meant to tap their general knowledge, not their memory for what they recently encountered. In addition, though not completely independent, we can analyze the cost of exposure to misleading content to their ability to answer correctly.

Prior work has shown that younger adults are quite vulnerable to such semantic illusions, often failing to notice contradictions to their stored knowledge (e.g., Fazio & Marsh, 2008; Marsh & Fazio, 2006; Shafto & MacKay, 2000, 2010), and suffer negative memorial consequences from them as well. For example, when answering distorted questions like, “How many animals of each kind did Moses take on the ark?”, younger

adults often fail to notice the contradiction with demonstrated knowledge (previously showing that they knew it was Noah who took animals on the ark) and answer “two” (Erickson & Mattson, 1981; see also, Baker & Wagner, 1987; Bredart & Docquier, 1989; Bredart & Modolo, 1988; Büttner, 2007; Kamas, Reder, & Ayers, 1996; Reder & Kusbit, 1991). They also reproduce these errors when later answering related general knowledge questions (answering “Who is said to have taken two animals of each kind on the ark?” with “Moses;” Bottoms et al., 2010). In addition, younger adults show memorial consequences after reading fictional stories that have erroneous information in them that contradict general knowledge and reproduce those errors as answers for later related general knowledge questions (e.g., Marsh & Fazio, 2006). Thus, young adults’ prior knowledge does not prevent them from acquiring knowledge-related errors that they should be able to avoid.

### **1.3.1 Aging and Suggestibility to Semantic Illusions**

Across a number of different situations and to-be-remembered materials, older adults tend to be more susceptible to being misled than younger adults (e.g., Cohen & Faulkner, 1989; Karpel, Hoyer, & Tolia 2001; Mueller-Johnson & Ceci, 2004; Roediger & Geraci, 2007; Schacter et al., 1997; Thomas & Bulevich, 2006). Whether asked to remember famous names (Dywan & Jacoby, 1990), videos (Loftus, Levidow, & Duensing, 1993), or lists of highly related words (the Deese-Roediger-McDermott

paradigm; Norman & Schacter, 1997), older adults' memories are more influenced by misleading information, and they make more errors than do younger adults. These tasks typically require participants to recall or recognize information from particular events that they have somewhat recently experienced (i.e. episodic memory), for which they have well-documented deficits. Thus, increased vulnerability to suggestion is typically attributed to older adults' declines related to episodic memory function, including source monitoring deficits (Cohen & Faulkner, 1989; Hashtroudi, Johnson, & Chrosniak, 1989; Multhaup, de Leonardis, & Johnson, 1999). In such cases, older adults can glean no support from their intact prior knowledge for what car accidents or burglaries are typically like; they must depend on their degraded episodic memories (Hess, 1990). Even when knowledge supports initial encoding, older adults' prior knowledge cannot help them when the task requires recollecting the details of a recent episode. For example, in the DRM paradigm, knowledge is a pre-requisite for "sleep" to be activated upon hearing "bed, rest, tired," but deciding if "sleep" was presented is an episodic memory task involving recollection.

However, suggestibility following semantic illusions involves memory errors where prior knowledge is quite relevant. Thus far, in contrast to younger adults (as discussed above), there is some burgeoning evidence that older adults seem to be less vulnerable to misleading information that contradicts their prior knowledge than are

younger adults, with older adults acquiring and reproducing less erroneous content about the world than younger adults (Marsh, Balota, & Roediger, 2005; Parks & Toth, 2006). For example, in Marsh et al. (2005), older and younger adults encoded stories containing references to both correct information like "...paddling around the largest ocean, the Pacific Ocean" and erroneous information such as "...a trip to St. Petersburg, the capital of Russia." Later, they took a general knowledge short-answer test that contained questions that could be answered with story facts (e.g., What is the largest ocean on earth?; What is the capital of Russia?). Older adults were much less likely to reproduce the story errors as answers to related general knowledge questions compared to younger adults.

Such work currently remains in its infant stages, with almost no research further exploring age differences in the role of prior knowledge in semantic illusions. My dissertation is specifically focused on answering the following question: Why do older adults show reduced suggestibility following semantic illusions compared to younger adults? I aimed to more carefully tease apart possible explanations and investigate what role prior knowledge plays in this reduced suggestibility.

#### **1.3.1.1 Explanations for Older Adults' Suggestibility to Semantic Illusions**

There are multiple explanations for why older adults show reduced suggestibility following semantic illusions; here, I propose four possible explanations.

The *episodic memory failure account* focuses on older adults' episodic memory deficits as the underlying cause of older adults' reduced suggestibility to semantic illusions. As discussed above, older adults show declines in memories for various details of specific events (Craik & Jennings, 1992; Balota et al., 2000). Related to suggestibility following semantic illusions, older adults may be unable to remember the details of materials that they encounter within an experiment, including the misleading content. Neuropsychological test data has supported this hypothesis, with preserved episodic memory ability (measured with the Logical Memory and Associate Learning tests) predicting suggestibility (Marsh et al., 2005). That is, the better episodic memory older adults had, the more likely they were to later reproduce errors that they encountered in stories, even though those errors likely contradicted their stored knowledge. At least one other study supports the claim that age-related deficits in episodic memory may result in reduced memory for suggestion, as older adults were less able to later recognize post-event misinformation in an eyewitness memory paradigm (Mitchell, Johnson, & Mather, 2003). More generally, to the extent that older adults have poorer episodic memory for stories, questions, or other material containing factual inaccuracies, they may be less likely to reproduce the semantic misinformation therein. The involvement of episodic memory failures can take many forms and was examined within each of the five experiments here. Note that the *episodic memory failure account* suggests a possible benefit

of poorer episodic memory in aging, a deficit that provides them protection against acquiring erroneous content about the world.

The three other explanations I examined follow from older adults' intact general knowledge: the error detection account, the knowledge quantity account, and the knowledge reliance account. The *error detection account* suggests that given that older adults' knowledge remains intact and expands with age, they may be better at detecting contradictions to that robust knowledge and may spontaneously engage in error detection. In other words, they may be less likely to fall for semantic illusions, less likely to overlook contradictions with their prior knowledge. Broadly, older adults have intact error detection abilities in a variety of situations: When noting errors in rhythm synchronizations (Turgeon, Wing, & Taylor, 2010), correcting their mistakes in identifying certain digits on a screen (Rabbitt, 1979), and marking misspelled words (Mackay, Abrams, & Pedroza, 1999), older adults perform as well as younger adults in monitoring for errors. Similarly, older adults can be considered "knowledge experts" (Hoyer et al., 1989; Perlmutter, 1988; Schaie & Labouvie-Vief, 1974), and there is some speculation that experts may be less susceptible to semantic illusions (Reder & Cleeremans, 1990). Combined, these preserved abilities in older adults may make them particularly likely to catch contradictions with general knowledge and not fall for

semantic illusions. Schwartz (2002) provided intriguing anecdotal evidence for this possibility:

In my work on illusory tip-of-the-tongues, I developed a set of trick questions for which there was no correct answer (e.g., What is the name of Mercury's moon?)...only one college student out of nearly 200 detected a discrepancy (that Mercury has no moons). However, when I tried to conduct the study at a local senior center...the study was a washout because virtually every older adult detected the falsity of the questions. (p. 140)

The basic point here is that older adults' intact knowledge could potentially make errors contradicting their knowledge especially salient. In younger adults, better detection of such errors during semantic illusion scenarios leads to reduced later suggestibility (Marsh & Fazio, 2006; Eslick, Fazio, & Marsh, 2011). Thus, older adults' possibly heightened error detection could translate into reduced negative memorial consequences following exposure to misleading information. The account was investigated in Experiments 1 and 2.

The *knowledge quantity account* emphasizes the idea that older adults simply have more general knowledge, accumulated over their many more years of life, than do younger adults. Empirically, researchers find time and time again that older adults enter their experiments with more knowledge than younger adults, as discussed above (e.g., Botwinick & Storandt, 1980; Burke & Peters, 1986; Dahlgren, 1998; McIntyre & Craik, 1987; Mitchell, 1989; Perlmutter, 1978). Even though older adults show some difficulties in recalling their general knowledge (tip of the tongue states: Burke & Shafto, 2004) and



may be slower to answer, they still remember many more facts about the world correctly than younger adults (Botwinick & Storandt, 1980; McIntyre & Craik, 1987; Perlmutter, 1978). In the tip-of-the-tongue (TOT) literature, Brown and colleagues have drawn on this robust finding to explain why older adults often report experiencing more tip-of-the-tongue states than younger adults (e.g., Brown & Nix, 1996; Gollan & Brown, 2006). Typically, the age difference in TOTs is explained in terms of a processing deficit in aging, whereby the lexical connections in knowledge weaken with age (e.g., Burke, MacKay, Worthley, & Wade, 1991). However, a key point is that older adults sometimes also correctly retrieve more target words than younger adults. Together, this suggests that older adults' basic vocabulary knowledge compared to that of younger adults is relevant to the frequency of their tip-of-the-tongue states (Dahlgren, 1998). Thus, Brown and colleagues as well as others suggest that because older adults know more words, showing higher vocabulary scores than younger adults, they have more chances to experience tip-of-the-tongue states (Dahlgren, 1998; Gollan & Brown, 2006). The *knowledge quantity account* draws on the same logic: simply, their larger body of knowledge may make it more likely for older adults (compared to younger adults) to successfully bring their knowledge to bear after seeing and possibly falling for semantic illusions. The contribution of the *knowledge quantity account* to older adults' reduced suggestibility is examined in Experiments 3, 4, and 5.

A final explanation, the *knowledge reliance account*, also appeals to older adults' intact general knowledge but with the claim that older adults may have a tendency to rely on their preexisting knowledge more so than do younger adults. As discussed in detail above, older adults often rely on their prior knowledge to bolster their remembering. Reliance on knowledge can result in costs to memory such that older adults make more errors than younger adults, but it can also benefit older adults' remembering. Following semantic illusions, such reliance would be expected to protect them from acquiring and reproducing errors that contradict their correct stored knowledge. Therefore, prior knowledge may serve a more protective role for older adults than for younger adults because knowledge constitutes especially strong traces in memory compared to episodic memories for older adults. The contribution of this explanation to older adults' reduced suggestibility was addressed in all five experiments.

Note that the *knowledge reliance account* would predict that it is older adults' prior knowledge that comes to mind when answering related general knowledge questions, regardless of whether older adults are able to remember the materials and misleading content. That is, even without an episodic memory failure, older adults are likely to rely on their knowledge. There is some suggestion in the literature that episodic memory failures are *required* for older adults' to then rely on their prior knowledge to aid remembering. Prior knowledge clearly plays a role when older adults *cannot* remember

the details of an encounter (i.e., an episodic memory failure). That is, most people (especially younger adults) typically retrieve memories of specific events in response to memory prompts, and some evidence supports the idea that it is only when such memory is lacking that people rely on prior knowledge to fill in the gaps (e.g., Bayen, Nakamura, Dupuis, & Yang, 2000; Jacoby, 1999; Spaniol & Bayen, 2002). Of course, older adults often lack the accuracy and completeness of younger adults' memories for specific events, perhaps making them especially likely to rely on their prior knowledge instead. Some of the work reviewed above draws on this "strategic guessing" or "accessibility bias" (Jacoby, Marsh, & Dolan 2001) explanation of older adults' memory performance (e.g., Mather, Johnson, & de Leonardis, 1999). However, is it necessary for older adults (and others) to experience an episodic memory failure in order to rely on their prior knowledge? In examining evidence for the *knowledge reliance account* and the *episodic memory failure account*, I also assessed this possibility.

Of note is that these four explanations are clearly not mutually exclusive; each one could be, and likely is, involved in older adults' reduced suggestibility to semantic illusions. Thus, each account's explanatory power is likely a matter of degree.

## **2. Experiments 1 and 2: Age Differences in Error Detection in Semantic Illusions and Consequent Suggestibility<sup>2</sup>**

As discussed above, older adults have intact error detection abilities in a variety of situations (e.g., Mackay, Abrams, & Pedroza, 1999; Rabbitt, 1979; Turgeon, Wing, & Taylor, 2010). In addition, older adults' preserved knowledge bases mean that they have the knowledge necessary to notice the errors, which could consequently reduce suggestibility (*error detection* account). In contrast, prior research shows that young adults are quite poor at noticing the contradictions in semantic illusions, but when they do catch them, later suggestibility is reduced (Marsh & Fazio, 2006; Eslick et al., 2011). Experiments 1 and 2 focused on the possibility that older adults may show reduced semantic illusions and subsequent memorial consequences because they A) are better able to notice contradictions with pre-existing general knowledge and B) spontaneously do so, using two different semantic illusions: The Moses Illusion and learning from stories. Thus, my primary goal in these experiments was to examine whether there were any age differences in susceptibility to these semantic illusions. That is, how do older and younger adults compare in noticing errors that contradict their prior knowledge?

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<sup>2</sup> This chapter is modified from two published papers. Experiment 1 is from Umanath, S., Dolan, P. O., & Marsh, E. J. (in press). Aging and the Moses Illusion: Older adults fall for Moses but if asked directly, stick with Noah. *Memory*. Experiment 2 is from Umanath, S. & Marsh, E. J. (2012). Aging and the memorial consequences of catching contradictions with prior knowledge. *Psychology and Aging*, 27, 1033-1038.

The robust *Moses Illusion* is the best-known semantic illusion in which young adults often fail to notice contradictions with their preexisting knowledge when answering distorted questions like, “How many animals of each kind did Moses take on the ark?” and answer “two” (even though they later demonstrate that they know it was *Noah* who took animals on the ark). This illusion demonstrates a failure to bring to bear stored knowledge (Erickson & Mattson, 1981). Prior work indicates that knowledge plays a key role in the Moses Illusion, in that participants are more likely to notice errors when they are less semantically associated with the correct references (e.g., Nixon or Abraham versus Moses in place of Noah; Erickson & Mattson, 1981; van Oostendorp & de Mul, 1990). Thus, with intact error detection and knowledge, older adults could have been particularly skilled in catching errors in the Moses Illusion. The same argument applied for detecting errors in stories containing misleading content.

Secondarily, I examined whether there were any age differences in suggestibility, meaning age differences in memorial consequences of the semantic illusions. This was a novel question in the Moses Illusion (Experiment 1) and provided a replication of prior work (e.g., Marsh et al., 2005) in learning from stories (Experiment 2). I examined whether exposure to factual inaccuracies (in the distorted questions or stories) affected participants’ later answers to general knowledge questions. Answering distorted questions had the potential to teach misinformation to the learner, in the same sense that

reading errors in stories or encountering them in other sources often later misleads learners. This type of suggestibility has been demonstrated in younger adults, who are more likely to later answer “Who is said to have taken two animals of each kind on the ark?” with “Moses” after answering the distorted question (Bottoms, Eslick, & Marsh, 2010; see also, Kamas, Reder & Ayers, 1996). This question was particularly interesting to ask with older adults following the Moses Illusion, given evidence that older adults make fewer memory errors when misinformation in stories contradicts preexisting knowledge (discussed above, Marsh et al., 2005).

### ***2.1 Experiment 1: Age Differences in Error Detection and Memorial Consequences of the Moses Illusion***

In this study, I investigated the occurrence of the Moses Illusion in older and younger adults, as well as its memorial consequences. The experiment had three phases. First, the Moses Illusion was measured through an initial error detection phase wherein participants answered undistorted and distorted general knowledge questions while being explicitly asked to note errors; of primary interest were older and younger adults’ responses to distorted questions. Second, the memorial consequences of exposure to distorted questions were observed in a subsequent general knowledge test asking related short answer questions (e.g., Who took two animals of each kind on the Ark?). Third, participants took a multiple choice knowledge check to confirm what they knew,

so that all analyses could be restricted to items for which individuals had demonstrated knowledge.

## **2.1.1 Methods**

### **2.1.1.1 Participants**

Ninety-seven Duke University undergraduates participated for course credit or monetary compensation, and 65 older adults recruited through Duke University's Center for Aging registry participated for monetary compensation. Older adult participants were at least 65 years of age (average age: 77).

### **2.1.1.2 Design**

A 2 (Age: Younger, Older Adult) X 3 (Error Detection Question Form: Undistorted, Not Presented, Distorted) mixed design was used. Age was a between-subjects factor while error detection question form was manipulated within subjects. Of particular interest were age differences in error detection ability (measured from responses to distorted trials in the initial phase) and performance on the short-answer test (representing suggestibility).

### **2.1.1.3 Materials**

Sixty Moses Illusion questions were adapted from Bottoms et al. (2010) and are included in the appendix. Each critical question had an undistorted and distorted form; the *undistorted* question form included a correct reference to a fact (e.g., "*What phrase*

*followed 'To be or not to be' in Hamlet's famous soliloquy?")* whereas the *distorted* question form contained a plausible but misleading reference (e.g., *"What phrase followed 'To be or not to be' in Macbeth's famous soliloquy?"*). Across participants, each question was rotated through the three conditions (undistorted, distorted, not presented). The error prevalence was 50%, consistent with prior work (e.g., Bottoms et al., 2010; Hannon & Daneman, 2001; Kamas et al., 1996; Reder & Kusbit, 1991; van Jaarsveld, Dijkstra, & Hermans, 1997), meaning that participants encountered 20 undistorted and 20 distorted questions during the error detection phase. Question order was randomized for each participant.

The short-answer general knowledge questions targeted the facts referenced in the critical questions (e.g., *"Whose famous soliloquy contained the phrase, 'To be or not to be, That is the question'?"*). Participants answered 30 short-answer questions referencing 10 previously undistorted questions, 10 previously distorted questions, and 10 questions that had not been presented during the error detection phase.

Knowledge check items included the prompts from the short-answer test questions paired with three answer-choices: the correct answer (e.g., *Hamlet*), the misinformation from the distorted question (e.g., *Macbeth*), and "I don't know." All 60 critical questions were asked about on this knowledge check.



#### **2.1.1.4 Procedure**

Participants were told that they would take three different general knowledge tests. The first test was the error detection phase. Participants were warned that during this first general knowledge test, some questions would contain errors making them unanswerable and were given the following example: "You might be asked, 'In what mythology was Venus known as the Goddess of War?' However, Venus was the Goddess of Love, not War." Participants were told to answer only undistorted questions and to type "wrong" in response to distorted questions. Participants were discouraged from guessing wildly and instructed to type "I don't know" if needed. After this phase, participants worked on a filler task consisting of visuo-spatial puzzles for three minutes. Next, participants completed a second general knowledge test: the short-answer test, with a warning against guessing and the instruction to type "I don't know" as needed. Finally, participants took the multiple-choice knowledge check and then were debriefed. The entire experiment took about 30 minutes for younger adults and 45 minutes for older adults and was programmed using MediaLab and DirectRT experimental software (Jarvis, 2008a; Jarvis, 2008b).

## 2.1.2 Results

All results, unless otherwise stated, were significant at the .05 alpha level. Pair-wise comparisons were Bonferroni-corrected to the .05 level. A Geisser-Greenhouse correction was used for violations of the sphericity assumption of ANOVA.

One coder coded all responses, blind to condition. A second coder coded 10% of the trials, and Cohen's kappa was calculated to assess inter-rater reliability. Reliability was high for each phase of the experiment ( $\kappa = .99$  for the initial error detection phase and  $\kappa = .98$  for the short answer test), and the first author resolved the disagreements in coding.

### 2.1.2.1 Knowledge Check

Participants answered 79% of multiple-choice questions correctly on the knowledge check. Consistent with prior work showing that older adults typically demonstrate more knowledge, older adults answered more of these multiple-choice questions correctly ( $M = .83$ ,  $SD = .10$ ) than did younger adults ( $M = .74$ ,  $SD = .11$ ),  $t(160) = 5.37$ ,  $SED = .02$ , Cohen's  $d = .86^3$ .

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<sup>3</sup> As has been noted in prior work (Bottoms et al., 2010), the knowledge check is affected by the earlier experimental tasks. That is, exposure to distorted questions during the error detection phase reduces correct answers (for those specific questions) on the knowledge check, as compared to questions that tap information not encountered previously within the experiment (a baseline measure of knowledge). Key for present purposes is that older and younger adults were similarly affected by prior exposure to the distorted questions, answering about 7% fewer questions correctly on the knowledge check (OAs: from .84 to .77; YAs: from .74 to .66).

Critically, the analyses that follow included *only* those items that participants answered *correctly* on the final knowledge check. That is, they examine only those items for which participants had prior knowledge.

#### **2.1.2.2 The Moses Illusion**

I analyzed responses to distorted and undistorted trials during the initial error detection phase separately, consistent with prior work (e.g., Kamas et al., 1996; van Oostendorp & de Mul, 1990).

During the error detection phase, undistorted questions (which contained correct references) were answered in one of four ways: correctly, incorrectly, falsely detecting an error, or saying “don’t know.” The relevant data are in the top portion of Table 1; these data represent averages across participants, but similar conclusions were reached when the data were analyzed with items as the unit of analysis. Older adults answered more undistorted questions correctly ( $M = .74$ ) than did younger adults ( $M = .66$ ),  $t(160) = 2.89$ ,  $SED = .03$ , Cohen’s  $d = .49$ . Note that this age difference occurred even though the age groups were matched on prior knowledge since the data is conditionalized on their correct performance on the knowledge check. Participants made very few false alarms ( $M = .04$ ), and this did not differ as a function of age,  $t(1, 160) = 1.48$ ,  $SED = .01$ ,  $p = .14$ .

**Table 1: Proportion of questions answered correctly, incorrectly, identified as “Wrong” and labeled as “I Don’t Know.” Data are from the error detection phase as a function of age and question type, conditionalized on correct answers during knowledge check.**

**Note: Standard deviations are presented in parentheses. Correct answers were impossible for distorted questions; “Wrong” responses to undistorted questions represent false alarms. “Wrong” responses for distorted questions represent successful detection.**

Undistorted Questions				
	<u>Correct</u>	<u>Moses Illusion</u>	<u>“Wrong”</u>	<u>“I Don’t Know”</u>
Older Adults	.74 (.17)	---	.04 (.05)	.14 (.12)
Younger Adults	.66 (.16)	---	.03 (.04)	.24 (.13)
Distorted Questions				
Older Adults	---	.50 (.24)	.38 (.27)	.13 (.11)
Younger Adults	---	.41 (.21)	.38 (.25)	.20 (.17)

More important for present purposes were responses to the *distorted* questions (see the bottom portion of Table 1). For these unanswerable questions, correct answers were not possible. Thus, each distorted question was answered in one of three ways: incorrectly (if *any* response was given; a Moses Illusion), detected (if “wrong” was typed), or with an “I don’t know” response. Following the coding scheme of Erickson & Mattson (1981), *any* answer to a distorted question other than “wrong” or “I don’t

know” was counted as an occurrence of the Moses Illusion. First, the Moses illusion was observed in both age groups. Younger adults answered 41% of the distorted questions, in line with the typical size of the Moses Illusion (e.g., Bottoms et al., 2010), even though these were all items for which they later demonstrated knowledge on the knowledge check. Interestingly, older adults succumbed to the Moses Illusion more often, providing answers for 50% of the distorted questions,  $t(160) = 2.51$ ,  $SED = .04$ , Cohen’s  $d = .40$ . However, there were no age differences in ability to *catch* the errors; older and younger adults were equally likely to say “wrong” to the distorted questions ( $M = .38$ ),  $t < 1$ .

#### **2.1.2.3 Memorial Consequences: Short-Answer Test Responses**

The second research question involved an examination of memorial consequences. Did prior exposure to distorted questions differentially influence older and younger adults’ responses on the subsequent short-answer general knowledge test which referenced content from the error detection phase? Again, the following analyses were restricted to items for which the participants successfully identified the correct answers on the knowledge check. Again, similar conclusions were reached regardless of whether participants or items were treated as the unit of analysis.

Memorial consequences were observed: the error detection phase affected people’s responses on the general knowledge test. Table 2 shows the entire data set; this table includes correct responses for the interested reader, but our focus here and the

reported analyses involve misinformation answers (defined as the specific wrong answer suggested in the distorted version of each question; e.g., Moses). A 2(Age) X 3(Error Detection Question Form: undistorted, not seen, distorted) ANOVA was computed on these data (bottom portion of Table 2).

**Table 2: Proportion of correct and misinformation answers produced on the short-answer knowledge test as a function of age and error detection question form.**

**Note: Standard deviations are presented in parentheses.**

Correct Answers			
	<u>Undistorted Question</u>	<u>Not Presented</u>	<u>Distorted Question</u>
Older Adults	.81 (.19)	.73 (.21)	.75 (.22)
Younger Adults	.87 (.13)	.73 (.19)	.71 (.23)
M	.84 (.16)	.73 (.20)	.73 (.22)
Misinformation Answers			
Older Adults	.01 (.04)	.02 (.04)	.04 (.07)
Younger Adults	.001 (.001)	.01 (.04)	.06 (.11)
M	.01 (.02)	.02 (.04)	.05 (.09)

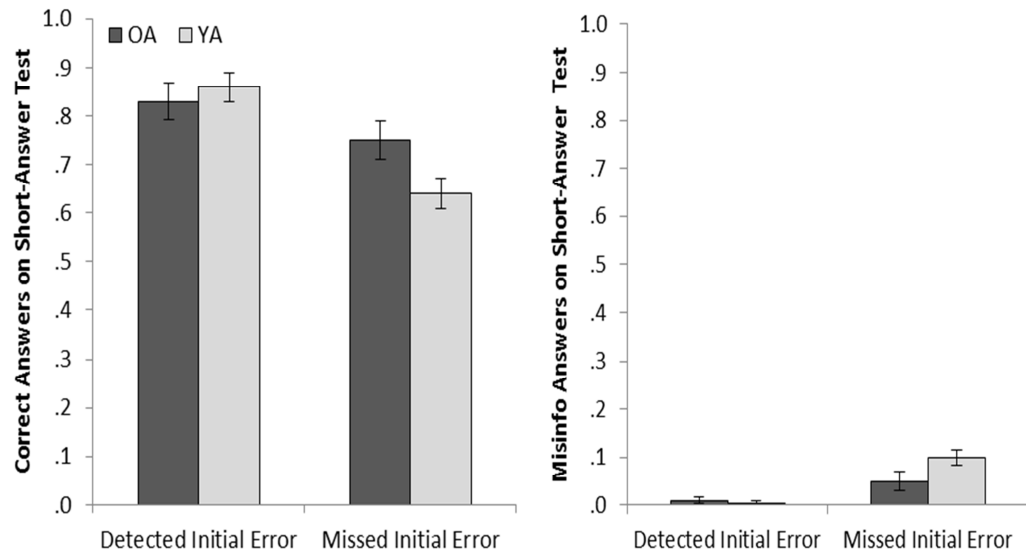
This ANOVA violated the sphericity assumption, and a Geisser-Greenhouse correction was applied. Even though participants knew the correct references (as confirmed on the knowledge check), they answered more questions with misinformation after exposure to

distorted questions ( $M = .05$ ) than after seeing undistorted questions [ $M = .01$ ;  $t(161) = 6.09$ ,  $SEM = .01$ , Cohen's  $d = .82$ ] or when the related questions had not appeared [ $M = .02$ ;  $t(161) = 4.93$ ,  $SEM = .01$ , Cohen's  $d = .62$ ;  $F(2,320) = 24.14$ ,  $MSE = .004$ ,  $\eta^2 = .13$ ].

Of interest were age differences in misinformation production (suggestibility). Younger adults showed a trend toward answering more short-answer questions with errors from the distorted questions ( $M = .06$ ) than did older adults ( $M = .04$ ), indicating that younger adults were slightly more suggestible than older adults. This was reflected in a marginally significant interaction between age and error detection question form [ $F(2,320) = 2.87$ ,  $MSE = .004$ ,  $\eta^2 = .02$ ,  $p = .058$ ]. Though suggestibility is low here, of note is this suggestibility occurred despite the fact that analyses were limited to items for which participants were able to demonstrate correct knowledge.

To better understand this pattern, I re-examined suggestibility based on whether errors were initially noticed or missed during the error detection phase, conducting 2(Age) X 2(Error Detected: Successful, Missed) ANOVAs on the proportion of short-answer questions answered correctly and the proportion answered with misinformation (see Figure 2). This analysis was limited to items for which participants had seen distorted questions during the error detection phase. When participants caught the errors, correct responding was high and suggestibility was low, and there were no age

differences. Regardless of age, catching an error was associated with correct responding on the short answer test.



**Figure 2: Correct answers (left) and misinformation answers (right) produced on the short-answer knowledge test as a function of age and error detection success.**

However, there were clear age differences in memorial consequences after errors were *missed* during the error detection phase. After missing an error, older adults were more likely to later produce the correct answer ( $M = .75$ ,  $SD = .25$ ) than were younger adults ( $M = .64$ ,  $SD = .30$ );  $t(155) = 1.82$ ,  $SED = .05$ , Cohen's  $d = .40$ ,  $p = .07$ , resulting in a significant interaction between age and successful detection,  $F(1, 127) = 4.86$ ,  $MSE = .06$ ,  $\eta^2 = .03$ . Similarly, as shown in the right panel, younger adults were more likely to reproduce misinformation after missing the errors ( $M = .10$ ,  $SD = .17$ ) than were older adults [ $M = .05$ ,  $SD = .09$ ;  $t(155) = -2.06$ ,  $SED = .02$ , Cohen's  $d = .39$ ], resulting in a



significant interaction between age and successful detection,  $F(1,127) = 5.44$ ,  $MSE = .01$ ,  $\eta^2 = .04$ . In short, older adults showed fewer memorial consequences, even though they demonstrated a larger semantic illusion during the error detection phase.

## **2.2 Experiment 2: Age Differences in Error Detection and Memorial Consequences of Learning from Stories<sup>4</sup>**

In this study, younger and older adults encoded stories containing factual inaccuracies; I manipulated whether errors contradicted well-known versus more obscure facts as this should have consequences for error detection. That is, participants should be better at detecting contradictions to well-known information, but older adults may have been better still. The stories also contained neutral references to facts without naming them explicitly, allowing us to estimate prior knowledge (which must be used to answer the related final questions, since the stories did not furnish the answers). Critically, half the subjects were explicitly instructed to mark errors, so I was able to evaluate older and young adults' ability to detect errors, with consequent differences in suggestibility on the final general knowledge test. Furthermore, by comparing older adults who were and were not explicitly asked to mark errors, I evaluated the possibility

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<sup>4</sup> Copyright © 2012 by the American Psychological Association. Adapted with permission. The official citation that should be used in referencing this material is Umanath, S. & Marsh, E. J. (2012). Aging and the memorial consequences of catching contradictions with prior knowledge. *Psychology and Aging*, 27, 1033-1038. No further reproduction or distribution is permitted without written permission from the American Psychological Association.

that older adults spontaneously engage in detecting errors that contradict their general knowledge.

## **2.2.1 Methods**

### **2.2.1.1 Participants**

Seventy-nine Duke University undergraduates participated for course credit, and 50 older adults, recruited through Duke University's Center for Aging database, participated for monetary compensation. Older adults were at least 65 years of age (average age: 77).

### **2.2.1.2 Design**

A 2 (Age: Young, Older Adult) X 2 (Instruction: Control, Detection) X 2 (Fact Knowledge: Well-Known, Obscure) X 3 (Fact Framing: Correct, Neutral, Misleading) mixed design was used. Age and instruction were between-subjects factors while fact knowledge and fact framing were manipulated within subjects.

### **2.2.1.3 Materials**

Two fictional stories, previously used with older adults (Marsh et al., 2005), were adapted from Marsh (2004). Each was approximately 1300 words and included characters, dialogue, and plot, as well as eighteen references to facts from the Nelson and Narens (1980) norms. Half of these references corresponded to well-known facts: An average of 70% of Nelson and Narens' subjects correctly answered questions probing

these facts. The others corresponded to obscure facts, with an average of 15% of Nelson and Narens' subjects answering related questions correctly. Within each story, one-third of the facts were presented in a correct frame providing the correct fact, one-third in a neutral frame making a general reference to the fact without naming it explicitly, and one-third in a misleading frame making a plausible but incorrect reference. For example, for a given fact, one subject read, "paddling across the largest ocean, the Pacific," another simply read a reference to "paddling across the largest ocean," and the third read, "paddling across the largest ocean, the Atlantic." The facts were rotated through the frame types across subjects. The general knowledge test consisted of 36 critical and 36 filler questions.

#### **2.2.1.4 Procedure**

Participants were told that they would read and listen to two fictional stories. The study was programmed using MediaLab and DirectRT experimental software (Jarvis, 2008a, 2008b). All participants received a general warning before hearing the stories, explaining that authors often take liberties with facts and that some information that they read/heard in the stories could be incorrect. One sentence at a time appeared on the screen accompanied by a voiceover. The voiceover for the stories was included to mitigate individual differences, particularly age differences, in reading speed. Control participants were simply instructed to press the "next" key when ready to move on.

Participants in the detection condition were asked to press one of two keys to advance to the next sentence: One key indicated readiness to move on; the other key indicated that the just-read sentence contained a factual inaccuracy. Before starting, participants read several practice sentences, including one with an error. If the subject missed the error, the experimenter pointed it out at the end of the practice session.

Participants then encoded the two experimental stories. To ensure attentiveness, ten catch trials were included on noncritical sentences where subjects were prompted to type what they just read/heard. Processing each story took about 15 minutes and was followed by a filler task. After solving visuo-spatial puzzles for ten minutes, participants took the general knowledge test. They were asked not to guess and to type "I don't know" if they could not answer a question. Finally, the participants were debriefed and received a list of the corrected facts on which they were misled. To ensure processing of the corrected versions, participants rated how surprising each one was on a 3-point scale. The entire experiment took about 1 hour.

### **2.2.2 Results**

All results, unless otherwise stated, were significant at the .05 alpha level. Pair-wise comparisons were Bonferroni-corrected to the .05 level. A Geisser-Greenhouse correction was used for violations of the sphericity assumption of ANOVA.

### 2.2.2.1 Error Detection During Story Reading

To see whether there were age differences in participants' ability to catch errors while reading, a 2 (Age) X 2 (Fact Knowledge) X 3 (Fact Framing) mixed ANOVA was computed on the proportion of critical sentences marked as containing errors. As shown in Table 3, participants caught some of the errors but missed more than half of them (54%). Participants discriminated factual inaccuracies from non-errors,  $F(2, 122) = 105.28$ ,  $MSE = .04$ ,  $\eta^2 = .62$ , correctly pressing the error key more for sentences containing misinformation ( $M = .46$ ) than they false alarmed to sentences containing correct facts ( $M = .20$ ;  $t(62) = 9.04$ ,  $SEM = .03$ ) or neutral references ( $M = .10$ ;  $t(62) = 12.68$ ,  $SEM = .03$ ). Participants were more likely to press the error key when sentences referred to obscure facts,  $F(1, 61) = 8.60$ ,  $MSE = .03$ ,  $\eta^2 = .12$ . Critically, this was qualified by an interaction with fact framing,  $F(2, 122) = 9.57$ ,  $MSE = .28$ ,  $\eta^2 = .13$ : Participants were just as good at catching contradictions of obscure facts as contradictions of well-known ones (both  $M$ s = .46), but they were more likely to mistakenly press the error key for correct references to obscure facts ( $M = .28$ ) than for correct references to well-known facts ( $M = .11$ ),  $t(62) = -4.58$ ,  $SEM = .04$ .

**Table 3: Proportion of story sentences labeled as containing errors, as a function of age, fact knowledge, and fact framing.**

**Note: Standard deviations are presented in parentheses.**

Older Adults			
Fact Knowledge	Fact Framing		
	<u>Correct</u>	<u>Neutral</u>	<u>Misleading</u>
Well-known	.09 (.14)	.07 (.14)	.52 (.26)
Obscure	.23 (.19)	.08 (.10)	.47 (.27)
<i>M</i>	.16 (.17)	.08 (.12)	.50 (.27)
Young Adults			
Well-known	.14 (.19)	.12 (.16)	.41 (.25)
Obscure	.32 (.29)	.12 (.18)	.44 (.25)
<i>M</i>	.23 (.24)	.12 (.17)	.43 (.25)

Of critical importance were any age differences in the ability to catch errors. Older and young adults pressed the error key equally often ( $F < 1$ ), and did so most often when sentences actually contained misinformation. Although the interaction between age and fact-framing was significant,  $F(2, 61) = 4.36$ ,  $MSE = .04$ ,  $\eta^2 = .03$ , older and young adults were equally good at catching story errors,  $t(61) = 1.17$ ,  $SEM = .06$ ,  $p =$

.25. However, young adults were slightly more likely to false alarm to correct statements than were older adults,  $t(61) = -1.82$ ,  $SEM = .04$ ,  $p = .07$ . Interestingly, though numerically the data in Table 3 suggest that older adults have been better at detecting well-known errors than younger adults, there was no hint of a three-way interaction,  $F < 1$ .

#### **2.2.2.2 Performance on the Final General Knowledge Test**

The next two sections examine performance on the final general knowledge test; two 2 (Age) X 2 (Fact Knowledge) X 2 (Instruction) X 3 (Fact Framing) mixed ANOVAs were computed, one on the proportion of questions answered correctly and the second on the proportion answered with misinformation. However, because fact knowledge did *not* affect successful error detection or the critical conclusions about age, the results that follow collapse over fact knowledge for simplicity. The complete data are shown in Tables 4 and 5 for the interested reader.

##### *2.2.2.2.1 Correct Answers on the Final General Knowledge Test*

As expected, participants were affected by what they had read in the stories, as reflected in a main effect of fact framing,  $F(2, 250) = 106.77$ ,  $MSE = .02$ ,  $\eta^2 = .44$ . Participants answered more questions correctly after reading correct facts ( $M = .64$ ) than after reading neutral references ( $M = .43$ ),  $t(128) = 12.45$ ,  $SEM = .02$ . Importantly, reading misinformation dropped later performance ( $M = .39$ ) below the neutral baseline,  $t(128) = 2.63$ ,  $SEM = .02$ , indicating that exposure to story errors reduced participants' ability to correctly answer final questions to below the level of their pre-existing knowledge.

Critically, the interaction between fact framing and instruction was significant,  $F(2, 250) = 4.78$ ,  $MSE = .02$ ,  $\eta_p^2 = .02$ , reflecting that only control subjects were affected by misinformation; subjects who were asked to mark errors via key-press answered just as many questions correctly after reading misinformation as after reading neutral references,  $t < 1$ .

**Table 4: Proportion of correctly answered questions on the final general knowledge test, as a function of age, instruction, fact knowledge, and fact framing.**

**Note: Standard deviations are presented in parentheses.**

	Control			Detect		
	<u>Correct</u>	<u>Neutral</u>	<u>Misleading</u>	<u>Correct</u>	<u>Neutral</u>	<u>Misleading</u>
<i>Older Adults</i>						
Well-Known	.73 (.22)	.63 (.28)	.53 (.23)	.83 (.18)	.68 (.27)	.68 (.19)
Obscure	.53 (.30)	.37 (.28)	.27 (.22)	.63 (.24)	.39 (.23)	.41 (.24)
M	.63 (.26)	.50 (.28)	.40 (.23)	.73 (.21)	.54 (.25)	.55 (.22)
<i>Young Adults</i>						
Well-Known	.79 (.20)	.51 (.26)	.34 (.23)	.75 (.17)	.52 (.29)	.53 (.25)
Obscure	.48 (.23)	.18 (.21)	.15 (.18)	.36 (.21)	.18 (.21)	.18 (.18)
M	.64 (.22)	.35 (.24)	.25 (.21)	.56 (.19)	.35 (.25)	.36 (.22)



Most important was whether any of the effects of story reading differed across age groups (see Table 4). Reflecting their greater semantic knowledge, older adults answered more questions correctly ( $M = .56$ ) than did young adults [ $M = .42$ ,  $F(1, 125) = 27.95$ ,  $MSE = .06$ ,  $\eta^2 = .18$ ]. Thus, it is crucial to consider the effects of story-reading in relation to each group's baseline prior knowledge, as reflected in the neutral condition where the stories did not provide any final test answers. Older and young adults showed similar costs from having read misinformation, both dropping about 5% from their neutral baselines after reading misinformation (from .52 to .48 for older adults; from .35 to .30 for younger adults). While participants benefitted from reading correct answers in the stories [OA:  $t(49) = 6.53$ ,  $SEM = .02$ ; YA:  $t(78) = 10.96$ ,  $SEM = .02$ ], the interaction between aging and fact framing was significant,  $F(2, 250) = 4.04$ ,  $MSE = .02$ ,  $\eta^2 = .02$ , showing that this benefit was greater in young adults than older adults.

To better understand how the detection instruction helped subjects avoid the costs of reading misinformation (as described above), I did an additional analysis linking success at error detection (while reading) to performance on corresponding general knowledge questions. This analysis was limited to subjects in the detection condition and items for which participants had read misinformation, and collapsed over questions about well-known vs. obscure facts (since fact knowledge did not affect the cost of story-reading). I computed a 2 (Age: YA, OA) X 2 (Error Detected During Story-

Reading: Successful, Missed) mixed ANOVA on the proportion of questions answered correctly. Participants answered significantly more questions correctly following successful error detection ( $M = .61$ ) than after missing errors ( $M = .32$ ),  $F(1, 61) = 50.04$ ,  $MSE = .05$ ,  $\eta^2 = .44$ . Interestingly, regardless of whether individual errors were caught or missed, older adults were more likely to answer general knowledge questions correctly ( $M = .57$ ) than young adults ( $M = .36$ ),  $F(1, 61) = 20.49$ ,  $MSE = .07$ ,  $\eta^2 = .25$ . That is, even after missing an error, older adults were more likely to later correctly answer the corresponding general knowledge question. To ensure that it was not simply that older adults knew more facts (reflected in their higher performance on questions that tapped neutrally-framed story facts), I repeated the analysis covarying out performance on the neutral questions. The main effect of age was still significant,  $F(1, 60) = 11.48$ ,  $MSE = .06$ ,  $\eta^2 = .15$ , indicating that when matched for prior knowledge, older adults were still better able to access their stored knowledge after exposure to misinformation than young adults, regardless of whether they had detected the errors.

#### 2.2.2.2.2 *Misinformation Production*

Of critical interest was participants' use of story errors to answer the final general knowledge questions (e.g., answering "What is the capital of Russia" with "St. Petersburg"). As shown in Table 5, replicating prior work, participants were far more likely to answer questions with misinformation if they had read the errors in the stories, as opposed to reading correct,  $t(128) = 13.08$ ,  $SEM = .02$ , or neutral references,  $t(128) =$

9.49,  $SEM = .02$ ;  $F(2, 250) = 103.69$ ,  $MSE = .03$ ,  $\eta^2 = .43$ . Detection instructions lessened the effects of having read misinformation in the stories,  $F(2, 250) = 5.85$ ,  $MSE = .03$ ,  $\eta^2 = .05$ : Misinformation production dropped from .31 in the control condition to .22 in the detection condition,  $t(127) = 3.00$ ,  $SEM = .03$ .

**Table 5: Proportion of misinformation answers on the final general knowledge test as a function of age, instruction, fact knowledge, and fact framing.**

**Note: Standard deviations are presented in parentheses.**

	Control			Detect		
	<u>Correct</u>	<u>Neutral</u>	<u>Misleading</u>	<u>Correct</u>	<u>Neutral</u>	<u>Misleading</u>
<i>Older Adults</i>						
Well-Known	.05 (.09)	.13 (.17)	.24 (.21)	.05 (.09)	.07 (.11)	.17 (.15)
Obscure	.03 (.08)	.07 (.11)	.25 (.20)	.05 (.10)	.10 (.17)	.21 (.19)
<i>M</i>	.04 (.09)	.10 (.14)	.25 (.21)	.05 (.10)	.09 (.14)	.19 (.17)
<i>Young Adults</i>						
Well-Known	.02 (.07)	.10 (.10)	.39 (.22)	.05 (.08)	.10 (.11)	.21 (.18)
Obscure	.01 (.04)	.09 (.13)	.35 (.23)	.06 (.12)	.11 (.14)	.28 (.24)
<i>M</i>	.02 (.06)	.10 (.12)	.37 (.23)	.06 (.10)	.11 (.13)	.25 (.21)

More important for present purposes, as reflected in a significant interaction between age and fact framing,  $F(2, 250) = 5.97$ ,  $MSE = .03$ ,  $\eta^2 = .05$ , older adults were less suggestible than young adults. After reading correct or neutral references, older and young adults were equally likely to answer with misinformation ( $ts < 1$ ), albeit quite rarely (see Table 5). However, older adults were significantly less likely to answer general knowledge questions with misinformation they had read in the stories ( $M = .22$ ) than were young adults ( $M = .31$ ),  $t(127) = -3.01$ ,  $SEM = .03$ . Critically, the 3-way interaction between age, instruction, and fact framing was not significant,  $F(2, 250) = 1.24$ ,  $MSE = .03$ ,  $\eta^2 = .01$ ,  $p = .29$ , though numerically, it seemed that younger adults may have benefitted more from the explicit instructions to detect errors. Instruction did not change the conclusions about age and suggestibility: Attempting to detect story errors reduced later suggestibility equally for both older and young adults.

To further explore the age difference in suggestibility, an additional analysis linked success at error detection (while reading) to later reproduction of those errors on corresponding general knowledge questions. This analysis was limited to subjects in the detection condition and items for which participants had read misinformation, and collapsed over questions about well-known vs. obscure facts. Errors caught during the story-phase were less likely to be produced as answers on the general knowledge test. Only 9% of correctly identified errors were reproduced on the final test, whereas 36% of

missed errors were later used as answers. This was confirmed statistically with 2 (Age: YA, OA) X 2 (Error Detected During Story-Reading: Successful, Missed) mixed ANOVA on reproduced errors, which revealed a main effect of error detection,  $F(1, 61) = 58.32$ ,  $MSE = .04$ ,  $\eta^2 = .49$ . No other effects were significant,  $F_s < 1$ .

## **2.3 Discussion**

These studies directly examined the *error detection account* as a possible explanation for older adults' reduced suggestibility to semantic illusions. Of primary interest was a possible age difference in participants' error detection ability, or conversely, their susceptibility to two types of semantic illusions. In Experiment 1, older adults demonstrated *greater* vulnerability to the Moses Illusion compared to younger adults. That is, they were more likely to answer distorted questions than were younger adults (e.g., answering "What is the name of the Mexican dip made with mashed-up artichokes?" with "guacamole"). Of note here is that this age difference in vulnerability to the illusion existed in the face of knowledge of the correct reference (e.g., avocados). Similarly, in Experiment 2, older adults were no better than younger adults at detecting misinformation as they read the stories (missing 54% and 55% of errors, respectively). Thus, older adults were no better than younger adults at detecting errors that contradicted their stored knowledge.

While this result seemed surprising based on older adults' intact error detecting abilities and maintained general knowledge, the result was consistent with theories of cognitive aging, specifically, with older adults' increased susceptibility to proactive interference (see Winocur, 1982) and age-related inhibitory deficits (Hasher & Zacks, 1979, 1988). Knowledge constitutes strong traces in memory, and older adults tend to apply their preexisting knowledge to facilitate memory, often filling in gaps in their memories with schema-consistent information (e.g., Hess & Slaughter, 1990; Koutstaal et al., 2003). For instance, in Experiment 1, older adults may have been more likely than younger adults to experience proactive interference from the concept of "avocadoes" while processing a distorted question like "What is the name of the Mexican dip made with mashed-up artichokes?" The key problem for older adults was that the situation required inhibiting prepotent responses. That is, older adults likely found it very challenging not to reply to questions once the associated answer (e.g., guacamole) comes to mind, since they have difficulty refraining from producing responses (e.g., Hasher, Stoltzfus, Zacks, & Rypma, 1991). Once information is partially active, older adults tend to struggle to inhibit or suppress that potentially irrelevant information (e.g., Balota et al., 2000; Kensinger & Schacter, 1999; Malmstrom & LaVoie, 2002), even when explicitly asked to do so (e.g., Anderson, Reinholz, Kuhl, & Mayr, 2011; Duchek et al., 1995).

Moreover, because the detection instruction in Experiment 2 had similar effects (in magnitude) across ages, it indicated that spontaneous detection of errors (in the control group) did not vary as a function of age. That is, if older adults in the control condition were already noticing a large number of errors, the detection instruction should have had less of an impact for older adults than for younger adults. Though numerically, it appeared that this might have been the case, with younger adults benefitting more from the explicit detection instructions, the corresponding analyses were not significant. Thus, older adults' reduced suggestibility was unlikely to be due to differences in detection ability.

If older adults are no better at detecting errors than younger adults and do not spontaneously do so, why do they show reduced suggestibility following semantic illusions? Experiments 1 and 2 provided some insight regarding the other explanations of older adults' reduced suggestibility. These data were somewhat inconsistent with the idea that age-related declines in episodic memory drove the age differences in suggestibility. In Experiment 2, in the detection condition, I examined the probability that errors were reproduced on the final test, given that they were caught versus missed during story-reading. Of particular interest were missed errors; the *episodic memory failure account* would have predicted that missed errors would be more likely to persist for young adults, who would be better able to remember the new associations than

would older adults. This was exactly what was found in Experiment 1, in the face of stored knowledge. However, no age difference occurred in Experiment 2: Missed story errors were equally likely to persist, regardless of age. Since both studies found that older adults were less suggestible following the semantic illusions, these inconsistent findings suggested that episodic memory failures might not be critical to their reduced suggestibility.

Instead, the results from both experiments suggested that older adults' reduced suggestibility was linked to overlearned prior knowledge, such that they had a tendency to rely on their stored knowledge (in line with the *knowledge reliance account*). In Experiment 1, compared to younger adults, older adults were better able to use their correct knowledge after missing errors during the error detection phase. Again, younger adults reproduced missed errors at a higher rate, but older adults were more likely to produce correct answers after missing errors initially. Older adults did not suffer from memorial consequences of exposure to the errors to the extent that their younger counterparts did, even though all subjects had the requisite knowledge stored in memory. Thus, though older adults' prior knowledge did not protect them from falling for the illusion, it protected them on later memory tests. Similarly, in Experiment 2, older adults were better able to access their stored knowledge after exposure to misinformation and answered more questions correctly than younger adults, regardless



of whether they missed or detected an error. Older adults' potential reliance on their prior knowledge might have protected them from acquiring erroneous information about the world.

In addition, these experiments contributed to the literature that illustrates circumstances under which older adults show *reduced* suggestibility (e.g., Marsh et al., 2005, Parks & Toth, 2006), which lies in stark contrast to their greater vulnerability to suggestion in other paradigms. In both experiments, older adults were less suggestible than younger adults following semantic illusions, (albeit marginally so in Experiment 1), reproducing fewer suggested errors on the later general knowledge test. Although in Experiment 1, suggestibility was low, and the age difference was small, it was consistent with past work (Marsh et al., 2005) and with Experiment 2. Finding this age difference in suggestibility in two very different paradigms (the Moses Illusion and learning from stories) added weight to the claim that the relationship between aging and suggestibility may be different when misinformation targets knowledge rather than episodic experience.

### 3. Experiments 3 & 4: The Role of Demonstrated Knowledge in Suggestibility Following a Semantic Illusion

In a number of situations, as discussed in the Introduction, older adults show greater reliance on their knowledge than do younger adults. As a consequence, when prior knowledge is applicable, their memory performance can sometimes improve significantly more than that of younger adults. Such reliance on their knowledge is one possible explanation (the *knowledge reliance account*) for older adults' reduced suggestibility to semantic illusions, with older adults relying on their stored knowledge to answer the final general knowledge questions, regardless of exposure to and memory of misleading content. Beyond ruling out the *error detection account*, the results of Experiments 1 and 2 suggested that *knowledge reliance* might play an important role in older adults' reduced suggestibility following semantic illusions since older adults were able to answer more related general knowledge questions correctly than younger adults after exposure to story errors.

In contrast, evidence from Marsh et al. (2005) suggested that episodic memory failures were the key to older adults' reduced suggestibility as preserved episodic memory ability predicted suggestibility in their work. That is, the better older adults' episodic memory abilities—meaning that they were probably better able to remember the stories—the more likely they were to reproduce story errors as answers to later

general knowledge questions. This explanation could not be ruled out as Experiments 1 and 2 found different results in terms of the possible involvement of episodic memory failures in older adults' reduced suggestibility.

Experiments 3 and 4 were aimed at examining the contributions of both these explanations in older adults' reduced suggestibility following semantic illusions. Again, I expected that both the *episodic memory failures account* and the *knowledge reliance account* provided some degree of explanation of the age difference. A direct measure of individuals' preexisting knowledge provided the opportunity to observe the contribution of each of these accounts. For example, implementation of a knowledge check, like that typically used in the Moses Illusion literature (and in Experiment 1), allowed a means to directly investigate *knowledge reliance*. That is, with an assessment of individual participants' prior knowledge, I was able to examine the possible age difference in suggestibility following semantic illusions when older and younger adults definitely had the correct knowledge stored in memory. Was having the correct knowledge stored in memory equally protective for older and younger adults or did older adults rely more heavily on their knowledge? In addition, a focus on information for which participants did not demonstrate knowledge provided a means to directly investigate when *episodic memory failures* were most likely to manifest. In other words, I was able to examine "new learning" of misinformation following semantic illusions

when the correct knowledge was not available in memory. Though episodic memory failures could have been involved when participants did demonstrate prior knowledge, their specific contribution was likely to be most evident when participants had no knowledge to draw upon when answering later general knowledge questions.

Previous work has typically used knowledge norms as representative of what correct knowledge participants were likely or unlikely to have stored in memory. This was problematic as the existing norms (Nelson & Narens, 1980; Tauber, Dunlosky, Rawson, Rhodes, and Silzman, in press) were not appropriate for aging studies; they were developed using only younger adults. They provided no information on older adults' general knowledge. Moreover, there is robust evidence indicating that older adults have more general knowledge than do younger adults (e.g., Botwinick & Storandt, 1980; McIntyre & Craik, 1987; Perlmutter, 1978). Relying on knowledge norms with age groups with large knowledge differences could have been misrepresenting age differences in suggestibility. Measuring each individual's knowledge prior to the experiment solved this issue.

In Experiments 3 and 4<sup>5</sup>, older and young adults took an initial general knowledge survey a few minutes before encoding stories containing factual

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<sup>5</sup> Note that Experiment 4 is a replication of Experiment 3 with the addition of a between-subjects manipulation that did not influence the critical results and thus, is included mainly as a replication. This is discussed in greater detail in the introduction to Experiment 4.

inaccuracies. Rather than using a post-experimental and multiple-choice knowledge check, I chose to use a pre-experimental short-answer test so as to get a stronger measure of the knowledge with which participants came to the experiment without contamination from the experimental materials themselves. Additionally, this initial general knowledge survey likely also made the relevant stored knowledge highly accessible immediately before participants were exposed to misleading content that contradicted that knowledge. This was expected to reduce overall suggestibility across age groups.

Of note is that in the studies of learning from stories that have examined suggestibility in younger adults following pre-experimental knowledge surveys, the evidence for the protective nature of prior knowledge has been mixed. In one study, younger adults were just as suggestible to misleading story information when they had demonstrated knowledge as when they had not (Fazio, Barber, Rajaram, Ornstein, & Marsh, 2013) whereas in another, younger adults were protected by their preexisting knowledge and used fewer story errors to answer later general knowledge questions than when they did not have stored knowledge (Mullet, Umanath, & Marsh, under review). Thus, it was unclear whether prior knowledge is at all protective against the memorial consequences of semantic illusions, let alone whether there might be age differences in that protection. I expected that when participants were able to

demonstrate correct knowledge initially, older adults might show greater reliance on their knowledge than younger adults, still reproducing fewer story errors as answers on the final general knowledge test. I also expected that younger adults would show more “new learning” of misinformation than older adults, such that younger adults would reproduce many more story errors when they did not demonstrate knowledge initially, indicative of a benefit of older adults’ degraded episodic memory abilities.

### **3.1 Experiment 3**

#### **3.1.1 Methods**

##### **3.1.1.1 Participants**

Forty-five Duke University undergraduates participated for course credit or monetary compensation, and 56 older adults, recruited through Duke University’s Center for Aging database, participated for monetary compensation. Older adults were at least 65 years of age (average age: 77). Six older adult participants who were unable to answer at least six initial general knowledge questions were excluded from the analyses, with the idea that these individuals may not have enough general knowledge to investigate whether it can protect them from picking up the misinformation in the stories (see also, Fazio et al., 2013). Thus, 45 younger adults and 50 older adults are included in the analyses below.

### 3.1.1.2 Design

A 2 (Age: Young, Older Adult) X 2 (Fact Framing: Neutral, Misleading) X 2 (Demonstrated Knowledge: No, Yes) mixed design was used. Age was a between-subjects factor and fact framing was manipulated within subjects. Demonstrated knowledge was allowed to vary within subjects across items.

### 3.1.1.3 Materials

The initial general knowledge survey contained 64 short-answer questions (e.g., *What is the name of a young sheep?*; from Nelson & Narens, 1980). Thirty-six of these questions corresponded to critical factual references that later appeared in the stories (e.g., *What is the unit of sound intensity?*), and the others were filler questions.

Two fictional stories, used previously with older adults (Marsh et al., 2005; Umanath & Marsh, 2012), were adapted from Marsh (2004). Each 1300 word story included characters, dialogue, and plot as well as eighteen references to facts from the Nelson and Narens' (1980) norms. The references ranged in difficulty from 3% to 84% of Nelson and Narens' subjects correctly answered questions probing these facts (average of 42%). Within each story, half of the facts were referenced in a neutral frame making a general reference to the fact without naming it explicitly, and half in a misleading frame making a plausible but incorrect reference. For example, for a given fact, one subject simply read a reference to "*cranked the volume more than it was supposed to be*" and another

read, *“cranked the volume amperes more than it was supposed to be.”* The facts were rotated through the frame types across subjects.

The final general knowledge test consisted of 36 critical questions (corresponding to items on the initial general knowledge survey and referenced in the stories) and 36 filler short-answer questions.

#### **3.1.1.4 Procedure**

Participants were instructed that the experiment consisted of three parts: an initial general knowledge survey, a story-reading phase, and a final general knowledge test. The study was programmed using MediaLab and DirectRT experimental software (Jarvis, 2008a, 2008b). First, participants completed the initial general knowledge survey on the computer. For each question, after providing a response and having been asked to respond with “I don’t know” rather than guess wildly, they rated their confidence in each answer on a 5-point Likert scale.

After completing visuo-spatial puzzles for three minutes, participants read and listened to two fictional stories. All participants were given a general warning before hearing the stories, noting that authors often take liberties with facts and that some information that they read/heard in the stories could be incorrect. One sentence at a time appeared on the screen along with a voiceover, and participants were simply instructed to press the “next” key when ready to move on. Before starting, participants read several



practice sentences, including one with an error (though no participants were given instructions to explicitly detect errors). To ensure attentiveness, 10 catch trials were included on noncritical sentences; subjects were prompted to type what they just read/heard. Processing each story took about 15 minutes and was followed by a filler task.

After solving more visuo-spatial puzzles for three minutes, participants took the final general knowledge test. They were asked not to guess and to type “I don’t know” if they could not answer a question. Finally, the participants were debriefed and rated their surprise on a corrected version of each fact. The entire experiment took about 1 hour and 30 minutes to complete for younger adults and about 2 hours for older adults.

### **3.1.2 Results**

All results, unless otherwise stated, were significant at the .05  $\alpha$  level. Pair-wise comparisons were Bonferroni-corrected to the .05 level. A Geisser-Greenhouse correction was used for violations of the sphericity assumption of analysis of variance (ANOVA).

#### **3.1.2.1 Initial Survey Performance**

Older and younger adults initially answered 64 open-ended general knowledge questions; these responses were coded as “correct,” “misinformation” if they matched the story-phase errors, “other wrong,” or “I don’t know.” For example, when asked

“What is the unit of sound intensity?,” *decibels* would be correct, *amperes* would be misinformation, and *hertz* would be coded as other wrong. The results are presented in Table 6.

Consistent with prior work, older adults not only showed intact knowledge, but more knowledge than the younger adults. They answered more initial general knowledge questions correctly than their younger counterparts [ $F(1, 93) = 25.36$ ,  $MSE = .05$ ,  $\eta^2 = .21$ ]. Conversely, younger adults answered more initial questions with “I don’t know” than did older adults [ $F(1, 93) = 32.63$ ,  $MSE = .05$ ,  $\eta^2 = .26$ ]. Older and younger adults came into the experiment with similar amounts of misinformation and other wrong answers.

**Table 6: Performance on the initial general knowledge survey as a function of age.**

**Note: Standard deviations are presented in parentheses.**

	Correct	“I Don’t Know”	Other Wrong	Misinformation
Younger Adults	.40 (.14)	.39 (.16)	.14 (.11)	.09 (.05)
Older Adults	.56 (.21)	.21 (.17)	.14 (.10)	.09 (.05)

### 3.1.2.2 Final Test Performance

The next sections examine performance on the final general knowledge test in terms of correct and misinformation responses. First, I analyzed the effect of exposure to misinformation on participants’ responses regardless of their prior knowledge. This was

done in order to first replicate the finding that older adults are less suggestible to semantic illusions and that they answer more questions correctly in the face of misinformation exposure than do younger adults. I computed two 2 (Age: Younger, Older Adult) X 2 (Fact Framing: Neutral, Misleading) mixed ANOVAs, one for correct answers and the other for misinformation responses.

Overall, participants' responses were affected by what they read in the stories. Both older and younger adults answered more questions correctly after seeing neutral references ( $M = .50$ ) than after being exposed to misinformation [ $M = .40$ ;  $F(1, 93) = 30.22$ ,  $MSE = .01$ ,  $\eta^2 = .24$ ] and were far more likely to answer questions with misinformation if they had read the errors in the stories ( $M = .32$ ) versus seeing neutral references [ $M = .09$ ,  $F(1, 93) = 92.83$ ,  $MSE = .03$ ,  $\eta^2 = .49$ ]. Yet, regardless of what they saw in the stories, older adults gave more correct responses on the final general knowledge test than did younger adults [ $M = .53$  versus  $.37$ , respectively;  $F(1, 93) = 17.22$ ,  $MSE = .07$ ,  $\eta^2 = .16$ ]. There was no interaction between age and fact framing,  $F < 1$ , for correct responses.

Younger adults were again more suggestible than older adults, reproducing more story errors as answers to related final general knowledge questions, seen in a significant interaction between age and fact framing [ $F(1, 93) = 3.95$ ,  $MSE = .03$ ,  $\eta^2 = .02$ ]. After reading neutral references, older and young adults were equally likely to answer with misinformation ( $M = .09$ ;  $t < 1$ ). Whereas, older adults were significantly less likely

to answer general knowledge questions with misinformation they had read in the stories ( $M = .26$ ) than were young adults ( $M = .37$ ),  $t(101) = -2.23$ ,  $SED = .04$ .

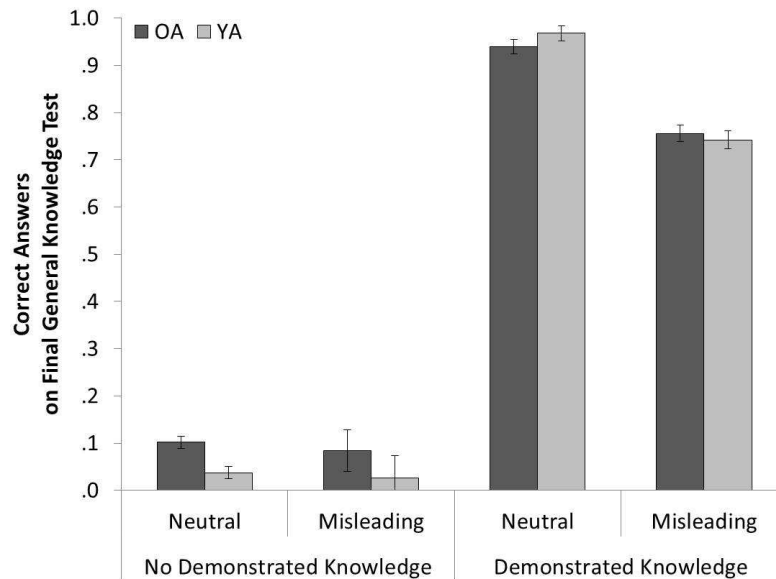
#### 3.1.2.2.1 *Suggestibility with Demonstrated Knowledge as a Factor*

Given that a participant did or did not demonstrate knowledge of a particular item, how did exposure to misinformation in a semantic illusion affect their responses on the final general knowledge test? To answer this question, I added *demonstrated knowledge* as a factor in the analyses, comparing final test performance given that participants initially answered a question with “I don’t know” or some other wrong answer (no demonstrated knowledge) versus when participants initially answered a question correctly (demonstrated knowledge). Thus, I computed two 2 (Age: Young, Older Adult) X 2 (Fact Framing: Neutral, Misleading) X 2 (Demonstrated Knowledge: No, Yes) mixed ANOVAs, for correct and misinformation answers on the final general knowledge test.

##### 3.1.2.2.1.1 **Final Correct**

These data are presented in Figure 3. Unsurprisingly, participants correctly answered more questions when they had demonstrated knowledge initially ( $M = .85$ ) versus when they had not [ $M = .06$ ;  $F(1,92) = 1831.02$ ,  $MSE = .03$ ,  $\eta^2 = .95$ ], and when they saw neutral story references ( $M = .51$ ) versus misleading story references [ $M = .40$ ;  $F(1,92) = 42.21$ ,  $MSE = .03$ ,  $\eta^2 = .31$ ]. However, participants’ correct responding was most affected by the misleading story references when they had demonstrated knowledge

initially,  $F(1,92) = 31.34$ ,  $MSE = .03$ ,  $\eta^2 = .25$ . Participants dropped from 96% correct for questions that had neutral references in the stories to 75% for misleading references [ $t(101) = 7.21$ ,  $SEM = .03$ ] indicating that exposure to errors resulted in a cost to participants' ability to answer correctly even though participants knew the correct answers. This pattern remained the same when I examined only the items that participants initially answered correctly with the highest level of confidence, with 98% correct for neutral references versus 81% for misleading references, [ $t(90) = 5.44$ ,  $SEM = .03$ ].



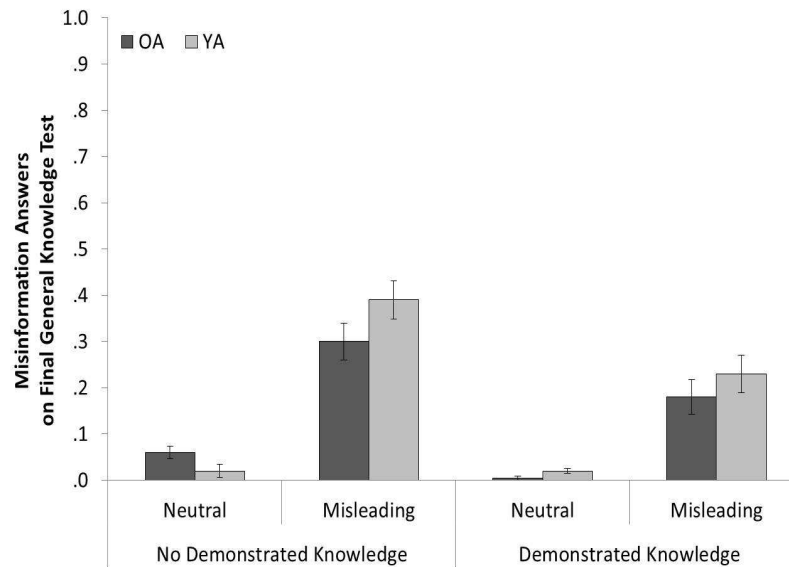
**Figure 3: Correct answers on the final general knowledge test as a function of age, demonstrated knowledge, and fact framing.**

Of critical interest were any age effects. A marginal interaction between demonstrated knowledge and age [ $F(1, 92) = 3.80$ ,  $MSE = .03$ ,  $\eta^2 = .002$ ,  $p = .054$ ] with a

significant follow-up t-test [ $t(101) = 2.17$ ,  $SED = .02$ ] suggested that older adults answered more questions correctly following no initial demonstration of knowledge ( $M = .09$ ) than did younger adults ( $M = .04$ ), regardless of whether they were exposed to misinformation in the stories. In contrast, there was no such age difference when participants had demonstrated knowledge initially ( $M = .73$  for older adults and  $.73$  for younger adults,  $t < 1$ ). This finding suggested that older adults gained access to more of their knowledge across the duration of the experiment as seeing any story references led older adults to generate more correct answers on the final test compared to younger adults. It also indicated that the initial measure of knowledge did not adequately capture the quantity of older adults' stored knowledge.

#### **3.1.2.2.1.2 Final Misinformation**

As illustrated in Figure 4, having knowledge was protective against suggestibility following semantic illusions such that participants were less likely to reproduce the misleading references they encountered when they had demonstrated knowledge initially ( $M = .11$ ) versus when they had not [ $M = .19$ ;  $F(1, 92) = 31.54$ ,  $MSE = .02$ ,  $\eta^2 = .12$ ]. Note that this means that participants still produced story errors 11% of the time even when they had demonstrated that they had the correct knowledge stored in memory.



**Figure 4: Misinformation answers on the final general knowledge test as a function of age, demonstrated knowledge, and fact framing.**

Interestingly, the 3-way interaction was marginally significant [ $F(1,92) = 2.97$ ,  $MSE = .02$ ,  $\eta^2 = .03$ ,  $p = .088$ ]. Demonstrated knowledge was equally protective for older ( $M = .18$ ) and younger adults ( $M = .23$ ,  $t < 1$ ), though it did not reduce suggestibility to floor. However, there was a slight age difference following no demonstrated knowledge. That is, after seeing factual inaccuracies in the stories, younger adults were slightly more likely to reproduce these story errors ( $M = .39$ ) than were older adults ( $M = .30$ ) when they had not initially demonstrated correct knowledge. This pattern of data suggested that younger adults might show greater new “learning” of misinformation. Because it was my intention to examine the possibility that episodic memory failures might drive older adults’ reduces suggestibility, I ran a focused follow-up 2 (Age) X 2 (Fact Frame)

ANOVA on misinformation answers for when participants initially had *not* demonstrated knowledge. Here, the interaction between age and fact framing was significant,  $F(1, 92) = 4.46$ ,  $MSE = .05$ ,  $\eta^2 = .02$ , indicating that when participants did not initially demonstrate knowledge, seeing the misleading information in the stories led younger adults to reproduce more story errors than older adults.

### **3.2 Experiment 4**

In this study, I was interested in understanding possible differences in the accessibility of memories, knowledge as opposed to recently encountered errors, when knowledge is assessed after exposure to misleading content in stories. Given the evidence showing older adults' broad susceptibility to proactive interference discussed in the Introduction, it would be no surprise that their considerable prior knowledge might interfere with their memory for the details of recent events. In the case of semantic illusions, such interference may actually protect older adults from acquiring errors about the world. In addition, there is some evidence to suggest that fast reaction times for answering general knowledge questions are correlated with confidence in those answers, supporting the idea that strong beliefs are likely to be retrieved quickly (Kelley & Lindsay, 1993). What initially pops to mind when participants are asked to answer general knowledge questions after exposure to erroneous content in stories—their stored well-learned knowledge or the recently seen errors? And importantly, is what comes to



mind first different for older and younger adults? In order to examine what participants initially think of, I introduced a speeded response instruction for the final general knowledge test to the procedure in Experiment 3: some participants were asked to answer the questions as fast as they could with the first answer that came to mind.

Though the manipulation of instruction was seemingly effective (those given speeded instructions responded to the final general knowledge questions more quickly than participants given control instructions), the final test instructions did not interact with any another factors in the study and did not affect memory performance. There were countless possible reasons for this pattern of data, so it was unclear that it was due to older and younger adults naturally providing the first response that came to mind. Because none of these reasons were directly tied to the theoretical explanations of older adults' reduced suggestibility tested and focused on here, I included this study mainly as a replication of Experiment 3 and discuss it as such.

### **3.2.1 Methods**

#### **3.2.1.1 Participants**

Forty Duke undergraduates participated for course credit or monetary compensation, and 44 older adults, recruited through Duke University's Center for Aging database, participated for monetary compensation. Older adults were at least 65 years of age (average age: 77). The following participants were excluded from further

analyses: 1 younger adult and 1 older adult performed more than two standard deviations below the mean on filler questions from the initial knowledge survey and/or the final general knowledge test; 2 younger adults and 1 older adult were unable to answer at least six initial general knowledge questions. These participants were excluded with the idea that these individuals may not have enough general knowledge to investigate whether it can protect them from picking up the misinformation in the stories (see also, Fazio et al., 2013). Thus, 37 younger adults (19 of whom were given Speeded instructions) and 42 older adults (22 of whom were given Speeded instructions) were included in the analyses below.

#### **3.2.1.2 Design**

A 2 (Age: Young, Older Adult) X 2 (Fact Framing: Neutral, Misleading) X 2 (Demonstrated Knowledge: No, Yes) X 2 (Final Test Instruction: Speeded, Control) mixed design was used. Age and Instruction were between-subjects factors, and fact framing was manipulated within subjects. Demonstrated knowledge was allowed to vary within subjects across items.

#### **3.2.1.3 Materials**

The materials were identical to those used in Experiment 3.

#### **3.2.1.4 Procedure**

The procedure followed that of Experiment 3 with one major change. For the final general knowledge test, critically, half of the older and younger adults received additional instructions to further guide their answering of these general knowledge questions: They were asked to answer as quickly as possible with the first answer that comes to mind, strongly emphasis on speed of response. To assist participants in adhering to the speeded response instruction and respond as quickly as they could, the final general knowledge test was oral such that all participants, regardless of instruction condition, verbally responded to the general knowledge questions. Verbal responding was instituted to increase the ease of responding, especially for older adults. Participants with the speeded instruction were reminded of that instruction periodically (every 8 questions); for parallelism, the other participants were reminded to speak clearly into the microphone. Furthermore, during the final test, the experimenter sat in the room with each participant, pressing the key in order to move the experiment on to the next question. This procedural element was introduced for two reasons: 1) to increase the likelihood of accurately recording reaction times by removing the necessity for participants to coordinate both responding to the question and pressing the correct key to move on and 2) to add a physical reminder to participants to follow instructions through the presence of the experimenter. The first two questions for all participants

were filler questions in order to acclimate them to the verbal responding. The entire experiment took about 90 minutes.

### **3.2.2 Results**

All results, unless otherwise stated, were significant at the .05  $\alpha$  level. Pair-wise comparisons were Bonferroni-corrected to the .05 level. A Geisser-Greenhouse correction was used for violations of the sphericity assumption of analysis of variance (ANOVA).

#### **3.2.2.1 Initial Survey Performance**

Performance on the initial general knowledge survey replicated that of Experiment 3. Older adults had more knowledge ( $M = .55$ ) than their younger counterparts [ $M = .39$ ;  $F(1, 75) = 23.72$ ,  $MSE = .04$ ,  $\eta^2 = .24$ ]. Conversely, younger adults answered more initial questions with “I don’t know” ( $M = .42$ ) than did older adults [ $M = .21$ ;  $F(1, 75) = 35.90$ ,  $MSE = .05$ ,  $\eta^2 = .32$ ]. Older and younger adults came into the experiment with similar amounts of erroneous knowledge, both answering 8% of the questions with misinformation. As expected, there were no differences in initial survey performance as a function of final test instruction or (later) fact framing,  $F_s < 1$ .

### 3.2.2.2 Final Test Performance

#### 3.2.2.2.1 Final Test Instruction Manipulation Check

To examine the effect of the final test instructions on participants' reaction times for answering questions on the final test, I computed a 2 (Age: Younger, Older Adult) X 2 (Fact Framing: Neutral, Misleading) X 2 (Demonstrated Knowledge: No, Yes) X 2 (Final Test Instruction: Speeded, Control) ANOVA on reaction times. Here, the reaction time data represented the amount of time it took participants to fully provide an answer to each question, and they were dependent on experimenter button-presses, so note that these were rough estimates of reaction time.

As expected, participants were slower to answer questions for which they had seen a misleading reference in the stories ( $M = 4649$ ) than ones for which they had seen a neutral reference [ $M = 4058$ ,  $F(1, 74) = 19.05$ ,  $MSE = 1422473$ ,  $\eta^2 = .20$ ]. Unsurprisingly, older adults were slower in their responses than younger adults [ $M = 5252$  versus  $3455$  milliseconds;  $F(1,74) = 28.13$ ,  $MSE = 8900171$ ,  $\eta^2 = .26$ ] and especially slowed down when they did not initially demonstrate knowledge [ $M = 5830$  without knowledge versus  $4674$  with knowledge,  $F(1, 74) = 12.57$ ,  $MSE = 1616052$ ,  $\eta^2 = .11$ ].

The purpose of the manipulation was to speed participants' responses to the general knowledge questions on the final test, with the idea that they would answer with the first answer that came to mind. Critically, the reaction time data indicated that the manipulation did affect participants' response times on the final test. Participants

who were given the speeded instructions answered questions more quickly ( $M = 3952$ ) compared to those in the control condition [ $M = 4755$ ;  $F(1, 74) = 5.62$ ,  $MSE = 8900171$ ,  $\eta^2 = .05$ ]. Thus, the manipulation of instructions was successful in leading participants to answer as quickly as possible in the speeded condition.

#### 3.2.2.2.2 Overall Performance on the Final Test

The results indicated that there were no differences in overall performance, either in correct responses or in misinformation responses, as a function of the final test instructions (main effects,  $F_s < 1$ ). The test instructions did not interact with either age ( $F_s < 1$ ) or fact framing ( $F_s < 1$ ) nor were there any 3-way interactions involving final test instructions ( $F_s < 1$ ). This indicates that overall final test performance was no different for participants who were encouraged to answer questions as quickly as possible with the first answer that came to mind and those who were not placed under such time pressure.

Otherwise, the overall results closely replicated those of Experiment 3. I only mention the critical replications here. Older adults gave more correct responses on the final general knowledge test than younger adults [ $M = .50$  versus  $.32$ , respectively;  $F(1, 75) = 21.28$ ,  $MSE = .06$ ,  $\eta^2 = .22$ ], regardless of the framing of facts in the stories or the final test instructions. Younger adults were more suggestible than older adults, reproducing more previously-seen story errors as answers to related final general knowledge questions, seen in a significant interaction between age and fact framing [ $F(1, 75) = 5.53$ ,  $MSE = .02$ ,  $\eta^2 = .04$ ]. After reading neutral references, older and young

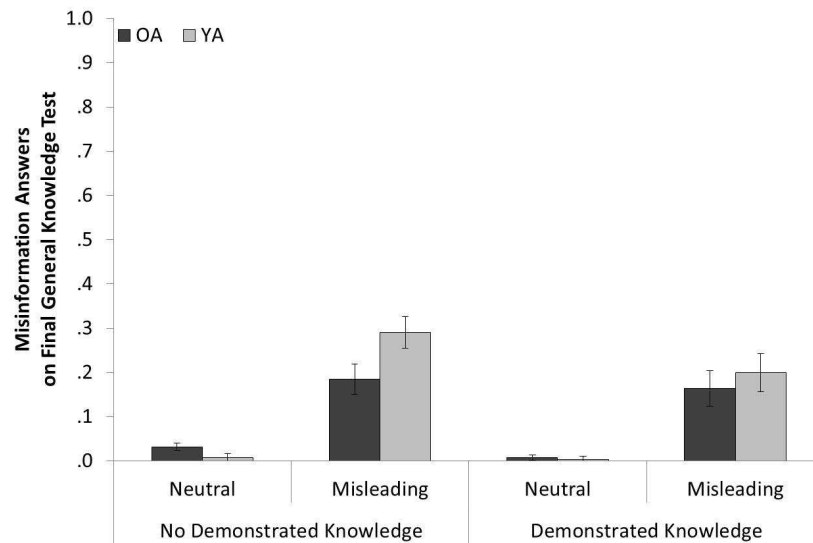
adults were equally likely to answer with misinformation ( $M = .08$ ;  $t < 1$ ). Whereas, older adults were significantly less likely to answer general knowledge questions with misinformation they had read in the stories ( $M = .21$ ) than were young adults ( $M = .30$ ),  $t(77) = -2.22$ ,  $SED = .04$ .

#### 3.2.2.2.3 Suggestibility with Demonstrated Knowledge as a Factor

Like Experiment 3, of interest was the effect of story reading specifically based on participants' initial survey answers, so I added *demonstrated knowledge* as a factor in the analyses. I computed two 2 (Age: Young, Older Adult) X 2 (Fact Framing: Neutral, Misleading) X 2 (Demonstrated Knowledge: No, Yes) mixed ANOVAs, for correct and misinformation answers on the final test. Again, final test instruction did not influence the pattern of data (none of the analyses involving final test instruction were significant for either correct responses or misinformation answers on the final test), and these data replicated the main findings of Experiment 3, so I include only the critical replications here.

A main effect of age indicated that again, older adult answered more questions correctly on the final test ( $M = .46$ ) than did younger adults [ $M = .40$ ;  $F(1,74) = 6.86$ ,  $MSE = .05$ ,  $\eta^2 = .08$ ], corroborating the finding in Experiment 3 that older adults gained access to more of their knowledge across the duration of the experiment. Note that here, this pattern held, regardless of what participants saw in the stories and whether or not they initially demonstrated knowledge.

As seen in Figure 5, having knowledge was again protective against suggestibility such that participants were less likely to reproduce the misleading references they encountered when they had demonstrated knowledge initially ( $M = .09$ ) versus when they had not [ $M = .13$ ;  $F(1, 75) = 4.91$ ,  $MSE = .02$ ,  $\eta^2 = .06$ ]. This, again, held true for both older and younger adults. Of note is that younger adults reproduced slightly more misinformation after exposure to misleading references (misinformation effect of 24%) than older adults (misinformation effect of 15%), regardless of whether or not they demonstrated knowledge initially, seen in a marginally significant interaction between fact framing and age,  $F(1, 75) = 3.46$ ,  $MSE = .04$ ,  $\eta^2 = .02$ ,  $p = .067$ .



**Figure 5: Misinformation answers on the final general knowledge test as a function of age, demonstrated knowledge, and fact framing.**



Though the relevant 3-way interaction was not significant [ $F(1,75) = 2.08$ ,  $MSE = .02$ ,  $\eta^2 = .03$ ,  $p = .15$ ], it might have been under-powered (observed power of .30), preventing the observation that it was when participants did *not* demonstrate knowledge that there was an age difference in suggestibility. Numerically (and illustrated in Figure 5), younger adults were more suggestible than older adults when they had not demonstrated knowledge initially (a misinformation effect of 28% versus 15% for older adults) than when they had (a misinformation effect of 20% versus 16% for older adults), indicating that younger adults showed greater new “learning” of misinformation.

Because it was my intention to examine the possibility that episodic memory failures might drive older adults’ reduced suggestibility, I ran a focused follow-up 2 (Age) X 2 (Fact Frame) ANOVA on misinformation answers for when participants initially did not demonstrate knowledge. Here, seen in a significant interaction between age and fact framing [ $F(1, 75) = 6.14$ ,  $MSE = .03$ ,  $\eta^2 = .04$ ] on misinformation responses, younger adults again showed greater new “learning” of misinformation after exposure to story errors ( $M = .29$ ) than did older adults ( $M = .19$ ). I also conducted the same ANOVA on misinformation answers following demonstrated knowledge. Though both groups answered more questions with misinformation if they had read the errors in the stories ( $M = .21$ ) versus seeing neutral references [ $M = .01$ ;  $F(1, 93) = 50.49$ ,  $MSE = .04$ ,  $\eta^2$

= .35] even though they had demonstrated correct knowledge for these items, neither the interaction between age and fact framing for correct responses nor that for misinformation answers was significant,  $F_s < 1$ . That is, prior knowledge was equally protective for both older and younger adults, though it did not reduce suggestibility to floor.

### **3.3 Discussion**

The results of Experiments 3 and 4 replicated previous findings that overall, older adults have more prior knowledge than do younger adults and also suffer fewer memorial consequences following semantic illusions than do younger adults (Marsh et al., 2005; Umanath, Dolan, & Marsh, in press; Umanath & Marsh, 2012). Prior knowledge was protective in terms of reducing suggestibility. Both older and younger adults reproduced fewer story errors when they had initially answered an item correctly rather than responded with “I don’t know” or another wrong answer. Critically, the present results provided evidence for and against different explanations of older adults’ reduced suggestibility. They were consistent with the *knowledge quantity* and *episodic memory failures accounts*, while also suggesting that the *knowledge reliance* was less important to explaining older adults’ reduced suggestibility here.

Intriguingly, demonstrated knowledge was equally protective for older and younger adults; there were no age differences in suggestibility for items for which

participants had initially provided the correct answer in Experiment 3 and only a suggestion of greater protection for older adults in Experiment 4. Thus, the *knowledge reliance* account, which holds that older adults rely on their preexisting knowledge more so than do younger adults, was not strongly supported.

In contrast, younger adults showed more “new learning” of misinformation compared to older adults. When participants did not demonstrate knowledge initially, misinformation responses were indicative of “new learning,” since participants could only have “learned” this erroneous knowledge from the stories (and did not come into the experiment with erroneous knowledge for these particular items). This indication of an underlying age difference was in line with the well-documented finding that older adults show difficulties in remembering new material (regarding narratives, see Adams, 1991; Cohen, 1979; Reder, Wible, & Martin, 1986) and suggested that episodic memory failures contribute to understanding older adults’ reduced suggestibility. While episodic memory failures are typically problematic for older adults and seen as a negative consequence of aging, here, the reduction in “new learning,” protected older adults from acquiring erroneous information about the world.

However, older adults’ larger (and less stable) knowledge base seemed to have the strongest influence on their overall reduced suggestibility, supporting the *knowledge quantity account*. When participants were able to demonstrate prior knowledge, it was

equally protective for older and younger adults. However, older adults came in with much more knowledge than their younger counterparts. With more knowledge to bring to bear, even if knowledge was equally protective for older and younger adults when they had it, older adults were likely to be more protected by that larger knowledge base (e.g., Dahlgren, 1998; Gollan & Brown, 2006). In addition, older adults gained access to even more of that knowledge base across the experiment. In both experiments, on the final general knowledge test, older adults answered more questions correctly than they initially did not show knowledge of than did younger adults, accessing more correct answers. This recovery likely contributed to older adults' reduced "new learning" of errors when they had not initially demonstrated knowledge.

These data indicated that the initial general knowledge survey was likely an underestimate of what older adults really knew through evidence of older adults' unstable access to their knowledge. The present measure of prior knowledge likely included both stable knowledge and marginal knowledge (Bahrick & Hall, 1991). Traditionally, marginal knowledge is defined in terms of procedure; it is knowledge that participants cannot produce but are able to correctly recognize. I use the term more broadly to include knowledge to which participants have variable access at different points in time. This finding suggested that further work was needed in understanding suggestibility in older and younger adults following stable versus marginal knowledge.

In sum, consistent with the *knowledge quantity account*, the larger store of knowledge that older adults possessed seemed to have driven their reduced “new learning” as they remembered even more correct answers during the course of the experiment, discarding the story errors. The age difference in misinformation answers when participants did not initially show knowledge was likely due to older adults’ gained access to marginal knowledge as well as some difficulties in learning the story errors. Therefore, older adults’ reduced suggestibility overall may come from the interplay between simply having more knowledge to bring to bear and thus, being protected from acquiring erroneous content about the world (*knowledge quantity account*) and some level of (beneficial) deficiency in learning new information (*episodic memory failures account*).

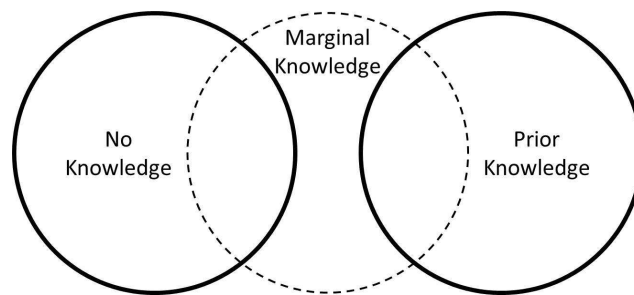
#### **4. Experiment 5: Age Differences in Suggestibility Following Semantic Illusions based on Stability of Access to Knowledge**

Older adults' access and utilization of their knowledge, while often intact, tends to be unstable (e.g., Barresi, Nicholas, Connor, Obler, & Albert, 2000), suggesting a large marginal knowledge base. This instability of access to their knowledge has been most clearly documented through findings that older adults suffer more often from tip-of-the-tongue states than do younger adults (e.g., Brown & Nix, 1996; Burke et al., 1991; Cohen & Faulkner, 1986; Lovelace & Twohig, 1990; for a review, see Burke & Shafto, 2004) and experience other changes in their semantic processing indicative of unstable access (see Burke & Light, 1981). Evidence from Experiments 3 and 4 was consistent with this literature, indicating that older adults' access to their general knowledge was less stable than that of younger adults: After having initially gotten an answer wrong or claiming that they did not know the answer, older adults were able to generate correct answers later on the final general knowledge test much more often than younger adults. Consequently, as Experiment 3 and 4 showed, their reduced suggestibility might not be driven by their knowledge serving an especially protective role compared to that of younger adults. Instead, their reduced suggestibility might result from access to more of their underlying knowledge base by the time of the final general knowledge test, consistent with the *knowledge quantity account*. That is, the age difference in suggestibility

following semantic illusions may have more to do with variable access to a larger knowledge base, in combination with some difficulties in learning story errors for which they did not have the contradictory correct knowledge stored in memory, than any special reliance on knowledge.

To more clearly understand the influence of older adults' knowledge on their reduced suggestibility following semantic illusions, a better initial measure of prior knowledge was needed. A single short-answer knowledge survey was a rather conservative measure of knowledge in the sense that participants had to be able to generate the correct response in order to demonstrate knowledge. This measure could have been improved in several ways. One possible improvement would have been to make the initial knowledge survey "easier," such that it would capture more of what participants, especially older adults, know. For example, a multiple choice initial knowledge survey would have likely captured more of people's knowledge, providing a more accurate measure of the general quantity of knowledge with which participants come into the experiment. However, doing so would have also lumped together qualitatively different types of knowledge: prior knowledge to which participants might consistently have access (stable knowledge) and less stable, marginal knowledge to which they only sometimes had access. Again, I use the term "marginal knowledge" in a broader conceptual sense but include the original definition used by Bahrack & Hall

(1991) who defined it as knowledge that participants could recognize but not produce. The single short-answer test used in Experiments 3 and 4 already created this issue with evidence of knowledge that participants, especially older adults, initially failed to demonstrate becoming accessible by the time of the final general knowledge test. Knowledge was measured and separated into “no demonstrated knowledge” and “demonstrated knowledge” (see solid-lined circles in Figure 6). However, these conditions were likely both “contaminated” by an unmeasured third category of knowledge, marginal knowledge (see dashed circle in Figure 6). This contamination likely obscured the relationship between older and younger adults’ suggestibility following semantic illusions and muddled the interpretability of Experiments 3 and 4.

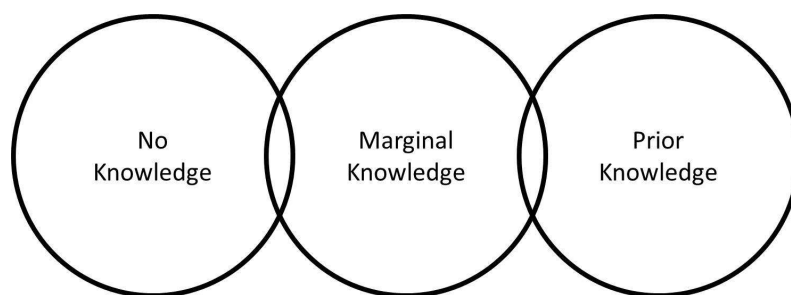


**Figure 6: Probable knowledge measure contamination using one initial short-answer knowledge survey (as in Experiment 3 & 4).**

A better approach for measuring prior knowledge would instead have allowed for separating these different qualities of knowledge: very stable knowledge, possibly less stable (and less routinely accessible) marginal knowledge, and when participants



truly do not have prior knowledge. In the present experiment, older and younger adults completed two knowledge surveys before exposure to stories containing misleading information and a final general knowledge test. The first knowledge survey took place two weeks prior to the rest of the study. Then, when participants returned for a second session, they completed a second knowledge survey, read the stories, and completed the final general knowledge test. As Figure 7 illustrates, performance on the two knowledge checks differentiated critical items for which they had stable, marginal, and no knowledge. Thus, items that participants answered correctly on both initial knowledge surveys were considered “stable,” and those that they never answered correctly (providing either “I don’t know” or other wrong answers on both knowledge surveys) were considered items for which they had “no knowledge.” Importantly, items that they answered correctly on only one of the initial surveys were categorized as “marginal.” Note that procedurally, this was a different way of defining marginal knowledge.



**Figure 7: Reduced knowledge measure contamination using two initial short-answer knowledge surveys (as in Experiment 5).**

Using two knowledge surveys separated by weeks should have also more cleanly separated items for which participants have these different levels of knowledge (pulling the circles representing different levels of knowledge apart in Figure 7, compared to Figure 6). Thus, this strategy for measuring prior knowledge allowed me to measure three qualities of knowledge and examine their possible differential influences on older adults' subsequent suggestibility to misleading information they read in stories. In addition, it also allowed for stronger definitions of what constituted stable, marginal, and no knowledge.

Because this change in the initial knowledge measure then split "prior knowledge" into three levels, there was a concern that the number of observations at each level of knowledge might be too few. I wanted to attempt to ensure that there would be enough observations to allow for the ability to detect differences in and draw conclusions about later memorial consequences and suggestibility. As such, I modified the materials to include more items that ought to have been easy to answer correctly for both younger and older adults. The details of the stimuli changes are provided below in the Materials section.

## **4.1 Methods**

### **4.1.1 Participants**

67 Duke undergraduates participated for course credit, and 53 older adults, recruited through Duke University's Center for Aging database, participated for monetary compensation. Older adults were at least 65 years of age (average age: 76). The following participants were excluded from further analyses: 2 older adults admitted to having looked up answers to the general knowledge questions between the sessions; 1 older adult failed to correctly answer the catch trials during the story-phase; 2 older adults and 1 younger adult were unable to answer at least six initial general knowledge questions. These participants were excluded with the idea that these individuals may not have enough general knowledge to investigate whether it can protect them from picking up the misinformation in the stories (see also, Fazio et al., 2013). Thus, 66 younger adults and 48 older adults were included in the analyses that follow.

### **4.1.2 Design**

A 2 (Age: Young, Older Adult) X 2 (Fact Framing: Neutral, Misleading) mixed design was used. Age was a between-subjects factor and fact framing was manipulated

within subjects. Prior knowledge varied within subjects but was not included as a factor in the analyses<sup>6</sup>.

### 4.1.3 Materials

The materials used in this experiment were heavily based on those used in Experiments 3 and 4. Importantly, 12 critical facts (of the 36 total) were removed and replaced. Based on previous data collected in the laboratory, I removed those facts for which either older or younger adults answered general knowledge questions correctly less than 30% of the time. I also removed those facts for which the difference in older and younger adults' correct responding was greater than 30%; in each of these cases, older adults showed more knowledge than younger adults. I replaced these facts with ones that had previously used as filler items that at least 40% of participants had answered correctly.

All the materials were modified accordingly. Both initial general knowledge surveys contained 64 short-answer questions (e.g., *What is the name of a young sheep?*; from Nelson & Narens, 1980). Thirty-six of these questions corresponded to critical factual references that later appeared in the stories (e.g., *What is the unit of sound*

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<sup>6</sup> The levels of knowledge were analyzed separately, and therefore, not included as a factor in the design. This was done because there were very different numbers of participants who demonstrated stable, marginal, and no knowledge. See Footnote 9 for further discussion.

*intensity?*), and the others were filler questions. However, again, 12 of the critical questions were replaced as discussed above. These two surveys were identical.

Two fictional stories, used previously with older adults (Marsh et al., 2005; Umanath & Marsh, 2012), were adapted from Marsh (2004). Each 1300 word story included characters, dialogue, and plot as well as eighteen references to facts from the Nelson and Narens' (1980) norms. Twelve of 36 total references were updated. The stories were also modified accordingly to accommodate these new critical references. Within each story, half of the facts were referenced in a neutral frame making a general reference to the fact without naming it explicitly, and half in a misleading frame making a plausible but incorrect reference. The facts were rotated through the frame types across subjects.

The final general knowledge test was adapted accordingly to consist of 36 critical questions (corresponding to items on the initial general knowledge surveys and referenced in the stories) and 36 filler short-answer questions.

#### **4.1.4 Procedure**

The procedure was similar to that of Experiment 3 except for one change. The experiment included two separate knowledge surveys, requiring two laboratory sessions. During the first session, participants took the first knowledge survey in the

lab. They returned approximately two weeks later<sup>7</sup> for the second session, during which participants took a second knowledge survey, then encoded the stories, and lastly, took the final general knowledge test. The first session took about 30 minutes while the second session took about an hour for younger adults and an hour and a half for older adults.

## **4.2 Results**

All results, unless otherwise stated, were significant at the .05  $\alpha$  level. Pair-wise comparisons were Bonferroni-corrected to the .05 level. A Geisser-Greenhouse correction was used for violations of the sphericity assumption of analysis of variance (ANOVA).

### **4.2.1 Prior Knowledge Levels**

On two initial knowledge surveys, older and younger adults answered 64 open-ended general knowledge questions; these responses were coded in the same manner as in Experiments 3 and 4. As described above, items that participants answered correctly on *both* initial knowledge surveys were considered “stable knowledge.” Items that they could answer correctly on *only one* of the initial surveys were categorized as “marginal knowledge.” Those items that participants *never* answered correctly, providing either “I

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<sup>7</sup> For older adults, the delay was on average 14.70 days (range of 10 to 21 days) and for younger adults, the delay was on average 14.68 days (range of 12 to 21 days).

don't know" or other wrong answers on both knowledge surveys, were considered items for which they had "no knowledge."

**Table 7: Initial knowledge levels as a function of age.**

**Note: Standard deviations are presented in parentheses.**

	No Knowledge	Marginal Knowledge	Stable Knowledge
Younger Adults	.39 (.13)	.08 (.05)	.47 (.14)
Older Adults	.23 (.18)	.12 (.07)	.59 (.21)

Table 7 includes the means for older and younger adult knowledge levels based on the two initial general knowledge surveys. As expected, older adults showed significantly more stable knowledge than did younger adults,  $F(1, 112) = 13.65$ ,  $MSE = .06$ ,  $\eta^2 = .11$ . Older adults also showed significantly more marginal knowledge than did younger adults,  $F(1, 112) = 15.79$ ,  $MSE = .01$ ,  $\eta^2 = .12^8$ . Thus, overall, older adults demonstrated knowledge of 71% of the general knowledge tapped in the study whereas younger adults showed only 55%. Younger adults showed a greater proportion of "no

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<sup>8</sup> Most of the marginal knowledge came from participants answering questions correctly on the second general knowledge survey: Older adults answered 21% of questions correctly while younger adults answered 10% correctly for which they had previously answered either "I don't know" or given another wrong answer. Participants much more rarely demonstrated correct knowledge on the first test and then could not produce the correct answer on the second test: 5% for older adults and 4% for younger adults. This pattern of data is consistent with older adults' word-naming failures and recoveries (e.g., Barresi et al., 2000).

knowledge” than did older adults,  $F(1, 112) = 30.26$ ,  $MSE = .04$ ,  $\eta^2 = .21$ . The low proportion of “no knowledge” that older adults demonstrated was driven by the fact that several ( $n = 12$ ) older adults had either marginal or stable knowledge for all the items, never showing “no knowledge.” Importantly, there was no age difference in the proportion of misconceptions that participants produced initially,  $F < 1$ . Also, later fact framing did not interact with age for any level of initial knowledge.

#### **4.2.2 Final Test Performance (regardless of prior knowledge level)**

The next sections examine performance on the final general knowledge test in terms of correct and misinformation responses, regardless of initial knowledge, to ensure replication of the basic age effects seen in all the previous experiments. The results closely replicated the previous experiments. Critically, yet again, older adults gave more correct responses on the final general knowledge test than younger adults [ $M = .65$  versus  $.48$ , respectively;  $F(1, 112) = 17.92$ ,  $MSE = .08$ ,  $\eta^2 = .14$ ]. The interaction between age and fact framing was not significant ( $F < 1$ ) for correct responses.

Again, younger adults were more suggestible than older adults, reproducing more story errors as answers to related final general knowledge questions, seen in a marginally significant interaction between age and fact framing [ $F(1, 112) = 3.82$ ,  $MSE = .03$ ,  $\eta^2 = .02$ ,  $p = .053$ ]. After reading neutral references, older and young adults were similarly likely to answer with misinformation [ $M = .06$  versus  $.07$ ;  $t(112) = -1.22$ ,  $SED =$



.01,  $p = .22$ ]. Whereas, older adults were significantly less likely to answer general knowledge questions with misinformation they had read in the stories ( $M = .18$ ) than were young adults ( $M = .28$ ),  $t(112) = -2.37$ ,  $SED = .04$ .

I then conducted further analyses of final test performance conditionalized on participants' prior knowledge to examine what impact one's quality of knowledge has on the memorial consequences of exposure to misleading information during the story phase. The following sections focus on correct responses and suggestibility for older and younger adults at each level of prior knowledge<sup>9</sup>. Thus, I conducted 6 2 (Age: Young, Older Adult) X 2 (Fact Framing: Neutral, Misleading) mixed ANOVAs.

#### **4.2.2.1 With No Knowledge**

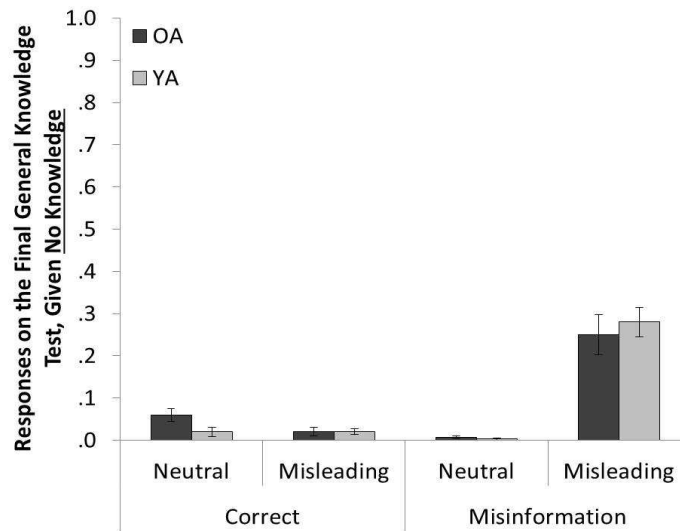
The following results were conditionalized upon when participants demonstrated no knowledge of particular items, providing "I don't know" or other wrong responses on *both* of the initial knowledge surveys, and included 36 older adults and all younger adult participants. With the use of stricter criteria for items for which

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<sup>9</sup> Separate ANOVAs on participants' correct and misinformation answers on the final test were conducted for each level of prior knowledge (stable, marginal, and no knowledge). Thus, it is not included as a factor in the design. The levels of knowledge were analyzed separately because there were very different numbers of participants who demonstrated stable, marginal, and no knowledge. Critically, for "no knowledge," 12 older adults had no observations; that is, across the two initial general knowledge surveys, they never demonstrated answering with either "I don't know" or another wrong answer on both. Similarly, for "marginal knowledge," 9 older adults and 25 younger adults had no observations, never answering a question correctly on one initial knowledge survey but not the other. Note, however, that all participants had observations for "stable knowledge." Because of the tremendous loss of data when including level of prior knowledge as a factor in the analyses, I chose to conduct the analyses for each level of knowledge separately.

participants were considered to have “no knowledge,” the findings were quite different from Experiments 3 and 4. Previously, when participants demonstrated a lack of knowledge initially, older adults showed greater later access to correct knowledge than younger adults and were also slightly worse at “learning” from the stories, with younger adults reproducing more story errors.

I expected that with the stricter criteria for “no knowledge” in place and a direct measure of marginal knowledge, there would be no evidence for further gains in access to knowledge for older adults. Yet, older adults were again able to answer more questions correctly on the final test ( $M = .04$ ) than were younger adults [ $M = .02$ ;  $F(1, 100) = 3.9$ ,  $MSE = .01$ ,  $\eta^2 = .04$ ,  $p = .051$ ], though marginally so, regardless of whether they were exposed to misinformation in the stories (see left panel of Figure 8). This finding suggested that older adults gained access to *still more* of their knowledge across the duration of the experiment. Even the inability to answer the critical general knowledge questions on two separate occasions did not truly capture items for which older adults had no prior knowledge.



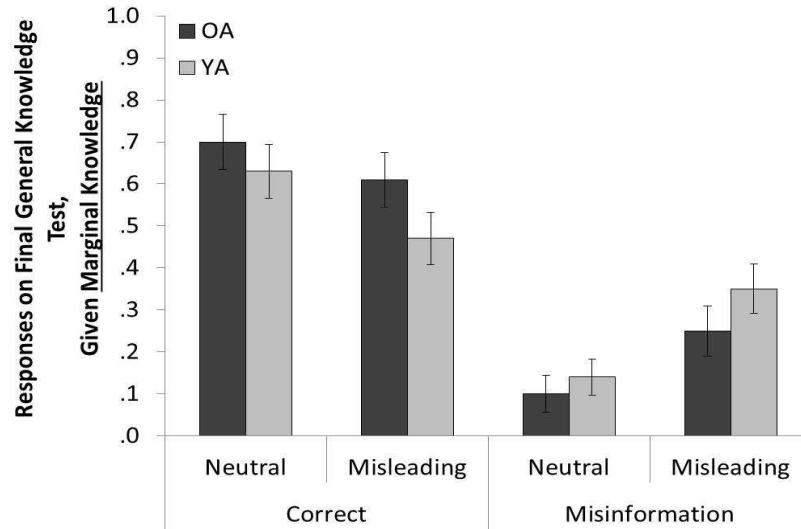
**Figure 8: Proportion of correct (left panel) and misinformation (right panel) responses on the final general knowledge test, given no knowledge, as a function of age and fact framing.**

In contrast to Experiments 3 and 4, there was no age difference in misinformation production when participants showed no initial knowledge,  $F < 1$  (see right panel of Figure 8). That is, when they had no prior knowledge and saw misleading content, older and younger adults were equally likely to “learn” the story errors ( $M = .27$ ) and reproduce them later, much more so than when they saw neutral references in the stories [ $M = .01$ ,  $F(1, 100) = 79.36$ ,  $MSE = .04$ ,  $\eta^2 = .44$ ]. The lack of age difference here with the stricter criteria for what it means for participants to have no prior knowledge indicated that older adults were able to learn just as much new information, albeit erroneous, as were younger adults; episodic memory failures were not the *major* contributor to older adults’ reduced suggestibility following semantic illusions.

#### 4.2.2.2 With Marginal Knowledge

The following results were conditionalized upon when participants demonstrated marginal knowledge of particular items, producing the correct answer on *only one* of the initial knowledge surveys, and included the 39 older adults and 41 younger adults who demonstrated such marginal knowledge. Examining suggestibility following marginal knowledge was especially of interest because this level of knowledge represented knowledge for which participants had shown unstable access across time. However, the conclusions that could be drawn from these data were tentative because of the low number of participants who demonstrated marginal knowledge, a limitation of the materials used.

Both age groups answered more questions correctly following neutral trials ( $M = .66$ ) than following story errors ( $M = .54$ ), indicating that seeing the errors in the stories negatively influenced their use of the correct marginal knowledge they had stored in memory,  $F(1, 78) = 4.396$ ,  $MSE = .14$ ,  $\eta^2 = .05$ . Older adults showed a trend towards answering more questions correctly following marginal knowledge ( $M = .65$ ) compared to younger adults ( $M = .55$ ) though the effect of age was not significant,  $F(1, 78) = 2.18$ ,  $MSE = .19$ ,  $\eta^2 = .03$ ,  $p = .14$  (see left panel of Figure 9). This finding lent some credence to the idea that older adults might rely on their knowledge, in this case marginal knowledge, more heavily than younger adults.



**Figure 9: Proportion of correct (left panel) and misinformation (right panel) responses on the final general knowledge test, given marginal knowledge, as a function of age and fact framing.**

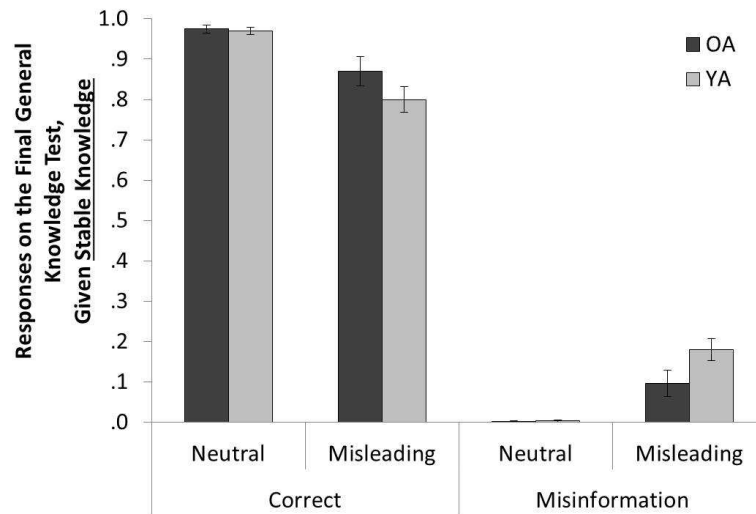
In terms of suggestibility, unsurprisingly, both age groups picked up more misinformation when they saw errors in the stories ( $M = .30$ ) rather than neutral references [ $M = .12$ ,  $F(1, 78) = 9.38$ ,  $MSE = .13$ ,  $\eta^2 = .11$ ]. Interestingly, there was a suggestion of an age difference in suggestibility for marginal knowledge (see right panel of Figure 9); regardless of what they saw in the stories, older adults reproduced numerically fewer story errors ( $M = .17$ ) compared to younger adults [ $M = .24$ ,  $F(1, 78) = 2.23$ ,  $MSE = .08$ ,  $\eta^2 = .03$ ,  $p = .14$ ]. This pattern hinted again that when participants had unstable access to their knowledge, older adults might have been less likely to learn the story errors and reproduce them later compared to their younger counterparts. But

again, the conclusions that could be drawn from suggestibility following marginal knowledge were quite tentative as the analyses were underpowered.

#### **4.2.2.3 With Stable Knowledge**

The following results were conditionalized upon when participants demonstrated stable knowledge of particular items, producing the correct answer on *both* initial knowledge surveys. Note that these analyses included all the participants. Again, with stricter criteria for items for which participants were considered to have “stable knowledge,” the findings were somewhat different from Experiments 3 and 4. Previously, when participants were able to demonstrate knowledge, there were no age differences in correct responding or in misinformation production on the final test.

Again, older and younger adults experienced costs to their correct responding: both age groups dropped from 97% correct for questions that had neutral references in the stories to 83% for misleading references;  $F(1, 112) = 45.85$ ,  $MSE = .02$ ,  $\eta^2 = .29$ . Seeing the misleading information in the stories reduced participants’ correct responding even though they had the correct knowledge stored in memory and demonstrated stable access to it (see left panel of Figure 10).



**Figure 10: Proportion of correct (left panel) and misinformation (right panel) responses on the final general knowledge test, given stable knowledge, as a function of age and fact framing.**

As expected, both groups answered more questions with misinformation if they had read errors in the stories ( $M = .14$ ) versus seeing neutral references [ $M = .003$ ;  $F(1, 112) = 39.48$ ,  $MSE = .03$ ,  $\eta^2 = .26$ ], even though they had demonstrated correct knowledge for these items *twice* over a two-week delay. This means that even stable knowledge was not completely protective against suggestibility following semantic illusions; participants still showed a 14% misinformation effect. Critically, in contrast to when participants had “demonstrated knowledge” in Experiments 3 and 4, exposure to misinformation appeared to have affected older and younger adults’ reproduction of story errors differently when they had stable knowledge (see right panel of Figure 10). Older adults were marginally less likely to reproduce story errors ( $M = .05$ ) compared to

younger adults [ $M = .09$ ,  $F(1, 112) = 3.50$ ,  $MSE = .03$ ,  $\eta^2 = .03$ ,  $p = .06$ ], regardless of what they read in the stories. This age difference was driven by a marginally significant interaction between age and fact framing [ $F(1, 112) = 3.33$ ,  $MSE = .03$ ,  $\eta^2 = .01$ ,  $p = .07$ ], indicating that older adults' reduced suggestibility came from reproducing fewer story errors following exposure to misinformation ( $M = .10$ ) than younger adults ( $M = .18$ ). That is, when participants had stable knowledge stored in memory, older adults were less likely to pick up misinformation compared to younger adults.

### **4.3 Discussion**

While these results replicated previous findings that overall, older adults had more prior knowledge than younger adults and were also less suggestible to semantic illusions than younger adults (Marsh et al., 2005; Umanath et al., in press; Umanath & Marsh, 2012), they also provided insight into how the stability of access to prior knowledge seems to have an important influence on suggestibility following semantic illusions. The pattern of data offered support for both the *knowledge quantity* and the *knowledge reliance accounts* and suggested that in fact, the *episodic memory failure account* may be less directly involved in older adults' reduced suggestibility following semantic illusions.

When prior knowledge was measured to provide better estimates of when participants had with no prior knowledge, marginal knowledge, and stable knowledge,



the memorial consequences following story exposure were quite different from those of Experiments 3 and 4. First, when participants demonstrated no prior knowledge across two initial knowledge surveys two weeks apart, there were no age differences in suggestibility; older adults reproduced just as many story errors as did younger adults. The lack of age difference here with the stricter criteria for what it means for participants to have no prior knowledge indicated that older adults suffered no particular decrement in learning the “new” (misleading) information in the stories, making the *episodic memory failures account* much less compelling. Moreover, these results suggested that the slightly increased suggestibility of younger adults in the “no demonstrated knowledge” condition in Experiments 3 and 4 was then likely driven less by older adults’ episodic memory difficulties and more by their recovery of access to marginal knowledge.

Second, knowledge played a key role in older adults’ reduced suggestibility.

Regarding *knowledge quantity*, older adults demonstrated more stable and more marginal prior knowledge compared to younger adults<sup>10</sup>. In addition, older adults gained access to slightly more (likely unstable) knowledge across the experiment; on the final general knowledge test, after demonstrating no prior knowledge, older adults answered more

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<sup>10</sup> In the case of older adults demonstrating more marginal knowledge than younger adults, the age difference was unlikely to be due to older adults looking up answers. After the first session, the experimenters asked the older adults participants not to look up answers and followed up with them at the second session. The two older adults who did admit to looking up answers were excluded from the analyses. Though younger adults were not systematically instructed against looking up answers between the sessions, their very low levels of marginal knowledge suggested that they too did not.

questions correctly than younger adults, albeit marginally. That is, even after two surveys of knowledge two weeks apart, older adults gained access to still more knowledge that they never demonstrated before. Older adults' overwhelming amount of prior knowledge and their continued unstable access to it clearly protected them from picking up misleading information that contradicts that knowledge.

The findings also provided some evidence that older adults might have been relying more heavily on their knowledge than did younger adults, supporting the *knowledge reliance account*. When participants had demonstrated marginal knowledge, the patterns of data for correct and misinformation answers showed trends such that older adults were more likely to answer questions correctly and less likely to reproduce story errors compared to younger adults. However, these were only trends and cannot be taken as strong evidence, as the accompanying analyses did not reach significance. The evidence from stable knowledge provided slightly stronger support for the *knowledge reliance account*. With the stricter measure of stable knowledge and with marginal knowledge separated into its own category, older adults appeared to have relied more on their stable knowledge than did younger adults. Older adults reproduced marginally fewer story errors in the face of stable knowledge compared to younger adults. Thus, stable knowledge was slightly more protective against suggestibility following semantic illusions for older adults than for younger adults. This reliance on

stable knowledge in combination with a lack of evidence for episodic memory failures heavily contributing to older adults' reduced suggestibility following semantic illusions lent further credence to the idea that episodic memory failures are not a prerequisite for older adults to rely on their preexisting knowledge. The implications of these overall findings are more thoroughly discussed, together with the evidence from the previous experiments, in the General Discussion that follows.

## **5. General Discussion**

When misleading content contradicts their prior knowledge (in semantic illusions), older adults broadly show reduced suggestibility compared to younger adults, reproducing fewer recently encountered errors. Older adults are not only less suggestible to learning errors that contradict their stored knowledge in fictional stories but also in the Moses Illusion, compared to younger adults. Even within the learning from stories paradigm, the present results replicated the Marsh et al. (2005) finding of older adults showing reduced suggestibility compared to younger adults in four different experiments, each with a slightly different methodology. These results indicate that when errors contradict preexisting knowledge, older adults are less likely to acquire those errors and are more likely to provide correct answers to later general knowledge questions, compared to their younger counterparts. Through five experiments, I examined *why* older adults show this reduced suggestibility following semantic illusions

and the possible protective role of older adults' intact prior knowledge. Based on the findings, I draw some conclusions below and offer some further speculation about the four explanations I investigated.

First, episodic memory failures seem to be involved in but perhaps do not drive older adults' reduced suggestibility to semantic illusions, both directly and in combination with *knowledge reliance*. Experiment 2 hinted at the possibility that episodic memory failures may not drive the age difference in suggestibility following semantic illusions with evidence that older adults reproduced just as many errors that they had initially missed during the story reading phase as did younger adults; the *episodic memory failures account* would have predicted that older adults would forget errors at a greater rate than would younger adults (which was found in Experiment 1). In Experiments 3 and 4, I was able to examine suggestibility following semantic illusions where participants did *not* have prior knowledge and therefore, where episodic memory failures were most likely to manifest as playing a role in older adults' suggestibility. Here, when participants did not demonstrate knowledge initially, older adults were less likely to produce story errors as answers to the final general knowledge questions than were younger adults. That is, younger adults showed more "new learning" of misinformation compared to older adults. This pattern suggested that episodic memory failures did play a role in older adults' reduced suggestibility following semantic

illusions, although in combination with other explanations. In fact, in Experiment 5, after demonstrating a lack of knowledge on two initial knowledge surveys two weeks apart (such that it seemed reasonable to assume that participants truly did not hold the correct knowledge in memory), older adults and younger adults reproduced the same proportion of story errors as answers to final general knowledge questions. The age difference in suggestibility when the requisite knowledge was lacking in memory disappeared. In addition, these data lend support to the small literature demonstrating that episodic memory failures are *not* required for older adults to rely on their knowledge (e.g., Koutstaal, 2003; Koutstaal et al., 2003; Smith, Rebok, Smith, Hall, & Alvin, 1983); older adults showed use of and reliance on their knowledge even when they did not demonstrate clear deficits in learning “new” (mis)information. Thus, while it would be presumptuous to rule out the involvement of the *episodic memory failure account*, the evidence indicates that when knowledge is lacking, older and younger adults learn just as much misinformation. *Episodic memory failures* could still be involved in combination with influences of knowledge.

Second, prior knowledge, however, does seem to drive the age difference in suggestibility following semantic illusions. But, older adults’ large and largely intact knowledge base does not make them any less susceptible to falling for semantic illusions and overlooking contradictions between presented information and their stored

knowledge. In Experiments 1 and 2, older adults were no better than younger adults at detecting errors that contradicted their stored knowledge, whether instructed to mark errors or not. Thus, there was no support for the *error detection account* as a contributor to older adults' reduced suggestibility following semantic illusions. In contrast, the *knowledge reliance* and *knowledge quantity* explanations both seem to be involved in older adults' reduced suggestibility following semantic illusions.

As demonstrated in Experiments 3, 4 and 5, prior knowledge *is* protective. Older and younger adults were less likely to reproduce the errors that they encountered if they had initially demonstrated having the (contradictory) correct knowledge stored in memory. Based on previous research indicating that older adults sometimes rely more heavily on their prior knowledge than do younger adults, I suspected that prior knowledge might be *even more* protective for older adults than for younger adults (the *knowledge reliance account*). That is, even when both age groups have prior knowledge, older adults would be less suggestible than younger adults, relying on their knowledge rather than the recently seen story errors to answer general knowledge questions. The evidence for this hypothesis is mixed. In some ways, older adults do seem to show a reliance on their knowledge: after exposure to misleading information, older adults were better able to cope with that exposure, discarding the misinformation and producing the correct information more often than did younger adults on the subsequent general

knowledge test in both Experiments 1 and 2. In contrast, in Experiments 3 and 4 when prior knowledge was directly measured, older and younger adults were equally likely to reproduce story errors after they demonstrated that they had the relevant correct knowledge stored in memory. The fact that demonstrated knowledge led to similar levels of suggestibility in older and younger adults seemed to indicate that older adults were not relying on their knowledge any more so than were younger adults. However, when stricter measures of prior knowledge were implemented in Experiment 5, stable knowledge was slightly more protective against suggestibility for older adults than for younger adults. That is, when participants had knowledge to which they demonstrated stable access, older adults were somewhat less likely to reproduce story errors, suggesting that they relied more on that knowledge to answer questions than did younger adults. This reliance is consistent with prior knowledge being automatically accessed and applied via top-down attention processes (Hess, 1990; Labouvie-Vief & Schnell, 1982).

Why is the evidence for the *knowledge reliance account* mixed? One possibility is that in Experiments 3 and 4, the “demonstrated knowledge” category of initial knowledge was contaminated with marginal knowledge in the same way that the “no demonstrated knowledge” category clearly was. That is, perhaps it included marginal knowledge to which participants later lacked access (see also, Barresi et al., 2000). The

pattern of data following participants' demonstrated marginal knowledge in Experiment 5 also allows for some speculation. When participants demonstrated marginal knowledge, older adults showed a trend such that they were more likely to respond with correct answers than were younger adults whereas younger adults showed a trend such that they were more likely to use story errors as answers than were older adults. Of course, these were just trends in the present data because of too few observations of marginal knowledge, but they suggest that perhaps when they have less stable knowledge, older adults might rely more heavily on their knowledge than the errors they recently encountered compared to younger adults. It could be the case that under such circumstances, older adults' greater susceptibility to proactive interference compared to younger adults manifests, with variably accessible knowledge constituting stronger traces in memory than recently encountered errors. Further work investigating unstable knowledge in older adults and subsequent suggestibility following semantic illusions is needed to better understand the current results regarding the *knowledge reliance account*. The murky data here reflects the state of the broader literature. There are many examples of knowledge bolstering older adults' memories and older adults relying on their knowledge more so than do younger adults, but there are also counterexamples where knowledge does not provide such differential help to older adults. It remains unclear under what exact circumstances older adults show a tendency



to rely on their knowledge, though knowledge does often play a role in their remembering.

Regarding the *knowledge quantity account*, across the three studies that had measures of participants' individual knowledge, older adults demonstrated more knowledge, both marginal and stable, compared to younger adults. Thus, even though in Experiments 3 and 4, demonstrated knowledge was equally protective against suggestibility for older and younger adults, older adults' larger base of knowledge clearly contributed to their overall reduced probability of reproducing errors. Simply, older adults have more knowledge than younger adults and are therefore, more likely to successfully bring it to bear, protecting them from picking up erroneous content about the world. Though this is a parsimonious explanation of older adults' reduced suggestibility following semantic illusions, it is somewhat unsatisfying in that it allows for the possibility that there is really nothing special about older adults at all—they just have more knowledge gained over longer lives than younger adults.

However, the present data add important nuance to the *knowledge quantity account*. Older adults' reduced suggestibility may come from more than simply having more knowledge than younger adults; it may result from older adults' varied accessibility to their knowledge, specifically, later access to more of their extensive knowledge bases. In Experiments 3 and 4, older adults demonstrated correct knowledge

on the final test that they failed to show initially, just an hour earlier. Incredibly, this same pattern occurred even after participants took two knowledge surveys two weeks apart in Experiment 5; older adults still showed a little more new access to previously undemonstrated correct knowledge during the final phase. Younger adults rarely showed such gains, certainly less so than did older adults.

Why might older adults show such gains compared to younger adults? This instability of access to knowledge in older adults could manifest as a result of again, simply having more knowledge available in memory. It is also consistent with the interplay between degrading controlled processes and intact automatic ones in aging (see also, Grieder, Crinelli, Koenig, Wahlund, Dierks, & Wirth, 2012), such that knowledge may come to mind for older adults in a spontaneous fashion that they are unable to fully control. For example, some work in the tip-of-the-tongue literature indicates that older adults often require more time to resolve their tip-of-the-tongue states (Burke et al., 1991), but if given enough time, are able to resolve almost all of them (Heine, Ober, & Shenaut, 1999).

Interestingly, anecdotal evidence suggested that older adults seem to be generally aware of this instability of access, beyond something like reporting tip of the tongue states. Several older adults commented to the experimenters that they wanted two different response possibilities when they were unable to generate the correct

answer: “I don't know” and “I don't remember,” to truly distinguish between information they were sure they did not have available in memory versus information they simply could not access at the time.

One older adult participant provided an especially poignant analogy for older adults' experience with their knowledge bases. He said that his memory was like a lazy Susan, a rotating tray used on a table to aid in moving food. As such, he said that different pieces of information would come in and out of his reach at different times as the lazy Susan of his memory rotated. Thus, at any given time, not all of his knowledge would be accessible, and he could not totally predict what would be accessible. However, he knew that an inability to remember something at a given time did not mean it was not in memory (not on the lazy Susan), just that it was out of reach temporarily and would likely come around eventually.

In addition, I would argue that perhaps older adults have a stronger tendency to persist in searching memory for presently inaccessible answers, compared to younger adults. For instance, after experiencing tip-of-the-tongue states, older adults show more spontaneous retrievals or “pop ups” of the correct answers compared to younger adults (Burke et al., 1991; Cohen & Faulkner, 1986). Regardless, these findings indicate that older adults have even more underlying knowledge than they are able to demonstrate at any given point in time. This unstable access to an enormous knowledge base provides

older adults with a unique protection against acquiring errors that contradict their knowledge as that knowledge becomes accessible over time.

Overall, these experiments indicate that prior knowledge is an important factor in understanding older adults' reduced suggestibility following semantic illusions and may even be the driving factor. Episodic memory failures are involved in much of older adults' memory performance and likely contribute to older adults' reduced suggestibility following semantic illusions, but they are not the only contributor and do not seem to be the most important contributor. Older adults may rely more heavily on their knowledge than do younger adults following exposure to misleading content in semantic illusions, but more research is needed to bolster the present data that suggest such a possibility. Older adults do have more knowledge to bring to bear than younger adults and thus, may be more likely to successfully do so in semantic illusions. Equally important to older adults' quantity of knowledge is the accessibility of that knowledge. Older adults gain access to more of their knowledge bases over time, resulting in reduced suggestibility following semantic illusions; marginal knowledge seems to be key.

The present findings add to a growing literature demonstrating the beneficial aspects of prior knowledge in older adults' remembering. Critically, they illustrate the importance of considering ways in which prior knowledge can be utilized to improve

and even protect older adults' memories. Just like any other stage of development, older adults have certain limitations and capacities that they must learn to cope with and optimize their cognitive abilities (Baltes & Baltes, 1993; Butler, 1974; Cohen, 2005; Labouvie-Vief, 1977; Labouvie-Vief & Schnell, 1982; Mergler & Goldstein, 1983; Perlmutter, 1988), and as researchers, it is imperative that we pursue the fruitful possibilities of using prior knowledge for optimizing memory in aging.

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- Umanath, S. & Marsh, E. J. (2012). Aging and the memorial consequences of catching contradictions with prior knowledge. *Psychology and Aging*, 27, 1033-1038.

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## Biography

### Born

June 16<sup>th</sup>, 1987 in Houston, TX

### Education

Duke University, Durham, NC

Ph.D., Psychology & Neuroscience, 2014

Certificate in College Teaching, 2014

Duke University, Durham, NC

M.A., Psychology, 2011

Washington University in St. Louis, St. Louis, MO

A.B., Philosophy-Neuroscience-Psychology & Ancient Studies

with a minor in Applied Statistics and Computation, 2009

### Publications

**Umanath, S.** & Marsh, E. J. (in press). Understanding how prior knowledge influences memory in older adults. *Perspectives on Psychological Science*.

Marsh, E. J. & **Umanath, S.** (in press). Knowledge neglect: Failures to notice contradictions with stored knowledge. In D. N. Rapp and J. Braasch (Eds.) *Processing Inaccurate Information: Theoretical and Applied Perspectives from Cognitive Science and the Educational Sciences*.

**Umanath, S.** & Berntsen, D. (in press). Personal life stories: Common deviations from the cultural life script. *Nordic Psychology*.

**Umanath, S.**, Dolan, P. O., & Marsh, E. J. (in press). Aging and the Moses Illusion: Older adults fall for Moses but if asked directly, stick with Noah. *Memory*.

**Umanath, S.** & Marsh, E. J. (2012). Aging and the memorial consequences of catching contradictions with prior knowledge. *Psychology and Aging*, 27, 1033-1038.

Marsh, E. J., Butler, A. C. & **Umanath, S.** (2012). Using fictional sources in the classroom: Applications from cognitive psychology. *Educational Psychology Review*, 24, 449-469.

Marsh, E. J., Lozito, J. P., **Umanath, S.**, Bjork, E.L., & Bjork, R.A. (2012). Using

- verification feedback to correct errors made on a multiple-choice test. *Memory*, 20, 645-653.
- Umanath, S.,** Butler, A. C. & Marsh, E. J. (2012). Positive and negative effects of monitoring popular films for historical inaccuracies. *Applied Cognitive Psychology*, 26, 556-567.
- Umanath, S.,** Sarezky, D., & Finger, S. (2011). Sleepwalking through history: Medicine, the arts, and courts of law. *The Journal of the History of the Neurosciences*, 20(4), 253-276.

### **Honors and Awards**

2013	American Psychological Association Dissertation Research Award Recipient
2013-2014	Phillip Jackson Baugh Fellowship Recipient (for the promotion of careers and interest in the areas of aging and human development)
2012-2013	Preparing Future Faculty Fellow
2011	National Science Foundation Nordic Research Opportunity Award Recipient
2010-2013	National Science Foundation Graduate Research Fellow
2009-2013	James B. Duke Graduate Fellow